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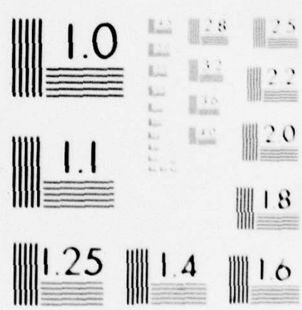

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A Summary Report

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THE ANALYSIS OF METHODOLOGIES AND TECHNIQUES FOR ESTIMATING SOVIET RESOURCE ALLOCATION.

VOLUME I. HIGHLIGHTS AND CURRENT RESULTS.

for

The Director of the Naval Analysis Program
Office of Naval Research

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(ONR Contract No. N00014 — 7-C-0676
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Dr. Gordon C. McMeekin
and
Rex D. Minckler
(Editor)

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GENERAL ELECTRIC COMPANY
CENTER FOR ADVANCED STUDIES
Net Assessment Programs Office
Suite 527, 777 14th Street, N. W.
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The overall objectives of ~~the~~ this research reflected in this summary report are to characterize and analyze current methodologies and techniques for estimating Soviet resource allocation and to identify and define possible new methodologies and techniques. The need for such research was highlighted during the course of a workshop sponsored by the Office of Naval Research (ONR) on economic conflict. A major topic on the agenda for this workshop was a discussion of the problems involved in estimating Soviet national security expenditures (NSE). The need for such research was also cited in a recent staff study by the Joint (over)

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19. KEY WORDS (continued)

- Biases and errors in estimation,
- Soviet military necessities and the technology transfer issue, and
- Production functions.

20. ABSTRACT (continued)

Economic Committee of Congress which recommended that "a determination should be made about the merits of the various methods for estimating Soviet defense spending".

The scope of this summary report therefore includes:

- Identification, categorization, and analysis of current techniques for estimating Soviet National Security Expenditures (NSE) and their associated numerical estimates;
- Development of an econometric evaluation methodology for formulating and testing statistical hypotheses based upon the estimation of possible information and methodology errors;
- Definition and performance of selected resource allocation experiments for the purpose of evaluating the level, composition, and rate of growth of estimated Soviet NSE;
- A discussion of the implications of alternative estimates of Soviet NSE from the standpoint of overall ex post Soviet resource allocation;
- An evaluation of the sectoral economic burden of Soviet NSE from the standpoint of ex post Soviet resource allocation;
- A review of the Bergendorff-Strangert Model for purposes of illustrating ex ante trade offs in resource allocation and the introduction of an energy constraint; and
- A review of the Stanford Research Institute and Wharton Econometric Forecasting Associates (SRI-WEFA) Econometric Model of the Soviet Union (SOVMOD III) as a proposed research tool for examining:
  - The need for expansion of the production function specification beyond the Cobb-Douglas case,
  - The projected economic burden of Soviet NSE by economic sector incorporating the generalized input-output methodology, and
  - The technology transfer issue and an hypothesis that the Soviet Union imports machinery from the West as a matter of military necessity.

The current baseline methodologies for estimating Soviet NSE which are identified and analyzed in this report may be summarized as follows:

- The Official Soviet Defense Budget (i.e., "Soviet estimates");
- The Original Budgetary Technique, i.e., International Institute of Strategic Studies (IISS) estimates;
- The FNE (Financing the National Economy) and BE (Budgetary Expenditure) Residuals Technique, i.e., Stockholm International Peace Research Institute (SIPRI) estimates;
- The Revised Budgetary Technique (i.e., Stanley Cohn's estimates);
- The Production Residual Estimation Technique (i.e., William T. Lee's estimates);
- The National Expenditure Method (i.e., French estimates);
- The Direct Costing Technique (i.e., CIA estimates); and
- The External Information Method (i.e., Chinese estimates).

A general ranking of the foregoing baseline estimation methodologies and their associated numerical estimates was performed on the basis of a series of twenty resource allocation experiments designed and conducted by GE-TEMPO, as the result of which the baseline estimation methodologies were assessed in terms of acceptability and robustness. (continued on next sheet)

20. ABSTRACT (continued)

An analysis of the economic burden of Soviet NSE was also conducted on the basis of a series of sixty-four resource allocation experiments designed and developed by GE-TEMPO, as the result of which:

- It was demonstrated that the estimated magnitude and the time trend of the aggregations of Soviet manpower and capital resources utilized in Soviet defense production is crucially dependent upon which baseline estimation technique is applied; and
- A relative ranking of Soviet economic sectors from the standpoint of Soviet NSE for the period 1966-1971 was formulated.

The summary report also provides a review and assessment of the following three well-known econometric models of the Soviet economy from the standpoint of illustrating the primary and secondary ex ante resource allocation effects associated with twelve ex ante resource allocation experiments which were designed and developed by GE-TEMPO:

- The Bergendorff-Strangert Model,
- The Niwa Model, and
- The Stanford Research Institute (SRI)-Wharton Econometric Forecasting Associates (WEFA) Soviet Econometric Model (SOVMOD III).

The report concludes with a series of recommendations with regard to additional experimental and methodological research.

THE ANALYSIS OF METHODOLOGIES AND TECHNIQUES FOR ESTIMATING SOVIET RESOURCE ALLOCATION

EXECUTIVE SUMMARY

INTRODUCTION

The overall objectives of the research reflected in this summary report are to characterize and analyze current methodologies and techniques for estimating Soviet resource allocation and to identify and define possible new methodologies and techniques. The need for such research was highlighted during the course of a workshop sponsored by the Office of Naval Research (ONR) on economic conflict. A major topic on the agenda for this workshop was a discussion of the problems involved in estimating Soviet national security expenditures (NSE).[1] The need for such research was also cited in a recent staff study by the Joint Economic Committee of Congress which recommended that "a determination should be made about the merits of the various methods for estimating Soviet defense spending".[2]

The scope of this summary report therefore includes:

- Identification, categorization, and analysis of current techniques for estimating Soviet National Security expenditures (NSE) and their associated numerical estimates;
- Development of an econometric evaluation methodology for formulating and testing statistical hypotheses based upon the estimation of possible information and methodology errors;
- Definition and performance of selected resource allocation experiments for the purpose of evaluating the level, composition, and rate of growth of estimated Soviet NSE;
- A discussion of the implications of alternative estimates of Soviet NSE from the standpoint of overall ex post Soviet resource allocation, as highlighted in Appendix A.

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[1] Economic Conflict and National Security Research by Rex D. Minckler and Richard G. Rebh, General Electric Company Center for Advanced Studies (GE-TEMPO), GE 77 TMP-5, Appendix D, February 22, 1977.

[2] Western Perception of Soviet Economic Trends by Ralph F. Kaufman for the Joint Economic Committee of Congress, March 6, 1978, page 18.

- An evaluation of the sectoral economic burden of Soviet NSE from the standpoint of ex post Soviet resource allocation, as highlighted in Appendix B;
- A review of the Bergendorff-Strangert Model for purposes of illustrating ex ante trade offs in resource allocation and the introduction of an energy constraint, as highlighted in Appendix C; and
- A review of the Stanford Research Institute and Wharton Econometric Forecasting Associates (SRI-WEFA) Econometric Model of the Soviet Union (SOVMOD III) as a proposed research tool for examining:
  - The need for expansion of the production function specification beyond the Cobb-Doûglas case, which is addressed in Appendix C;
  - The projected economic burden of Soviet NSE by economic sector incorporating the generalized input-output methodology which is described in Appendix B; and
  - The technology transfer issue and an hypothesis that the Soviet Union imports machinery from the West as a matter of military necessity, as reflected in Section 3.0 and Appendix C.

Current Baseline Methodologies

The current baseline methodologies for estimating Soviet NSE which are identified and analyzed in this report may be summarized as follows:

- The Official Soviet Defense Budget (i.e., "Soviet estimates");
- The Original Budgetary Technique, i.e., International Institute of Strategic Studies (IISS) estimates;
- The FNE and BE Residuals Technique (i.e., SIPRI estimates);[3]
- The Revised Budgetary Technique (i.e., Stanley Cohn's estimates);
- The Production Residual Estimation Technique (i.e., William T. Lee's estimates);
- The National Expenditure Method (i.e., French estimates);
- The Direct Costing Technique (i.e., CIA estimates); and
- The External Information Method (i.e., Chinese estimates).

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[3] FNE, BE, and SIPRI are abbrevations for the following terms: Financing the National Economy (FNE) component of the USSR State budget, Budgetary Expenditure (BE), and the Stockholm International Peace Research Institute (SIPRI).

A summary of the estimates of Soviet NSE utilizing the foregoing baseline methodologies is presented in Table i.

Table i

A Summary of Current Baseline Estimates of Soviet National Security Expenditures for the Period 1960-1975 [4] (billions of current rubles)

1	2	3	4	5	6	7	8	9	10	11
				Revised Budgetary Technique (Stanley Cohn's Estimates)		Production Residual Estimation Technique (Bill Lee's Estimates)				
Year	Official Soviet Defense Budget	Original Budgetary Technique (IISS Estimates)	FNE and BE Residuals Technique (SIPRI Estimates)	State Reserves Basis	Final Demand Basis	Establishment Basis	Commodity Basis	National Expenditures Method (French Estimates)	Direct Costing Technique (CIA Estimates)	External Information Method (Chinese Estimates)
1960	9.3	11.9	17.2	17.3	18.1	16.0	11.8*	21.0*	22.6	(18.7)
1961	11.6	14.6	18.1	20.3	20.9	18.5	12.9*	22.6*	24.1	20.4*
1962	12.6	16.1	20.9	22.3	22.9	21.0	14.2*	23.6*	25.7	22.2*
1963	13.9	17.8	21.0	23.4	25.5	23.0	15.5*	24.7*	27.3	24.2*
1964	13.3	17.6	21.9	24.5	23.9	24.5	16.9*	25.9*	29.1	26.4*
1965	12.8	17.4	25.0	29.6	23.5	26.0	18.3*	27.1*	31.0	28.8*
1966	13.4	18.4	25.9	28.3	23.7	28.0	22.2*	28.3*	33.0	32.0*
1967	14.5	20.0	26.9	26.8	25.8	32.5	28.3	29.6*	35.2	35.5*
1968	16.7	22.7	31.2	33.4	29.6	38.5	33.5	31.0*	37.5	39.5*
1969	17.7	24.4	33.9	37.1	32.2	42.0	36.8	32.4*	39.9	43.8*
1970	17.9	25.7	38.1	35.4	34.3	46.0	40.2	33.9*	42.5	(48.7)
1971	17.9	26.6	40.7*	38.6	35.7	50.0	43.4	35.4	45.3	53.0*
1972	17.9	27.5	43.6*	35.5	37.3	54.5	48.0	37.0	48.2	57.6*
1973	17.9	28.4	46.8*	38.9	40.2	60.5	53.4	39.7	51.4	62.6*
1974	17.7	28.8	50.3*	39.9	40.3	65.0	57.1	40.6	54.7	(68.2)
1975	17.4	29.1	54.1*	41.8	42.2	71.5	62.3	42.3	58.2	(72.6)
Average Rate of Growth 1960-1969	6.7%	8.3%	7.9%	7.9%	6.6%	11.0%	13.5%	4.6%	6.5%	10.0%
Average Rate of Growth 1970-1975	0.0%	2.5%	7.3%	2.8%	4.2%	9.0%	9.1%	4.6%	6.5%	8.7%
Average Rate of Growth 1960-1975	4.3%	6.1%	7.9%	6.0%	5.8%	10.5%	11.7%	4.6%	6.5%	9.5%
1970 NSE estimated share of the Soviet GNP (184.3 rubles)	.050	.064	.093	.094	.098	.087	.064	.117	.123	.101
Soviet National Security Expenditure Estimate	D_{1t}	D_{2t}	D_{3t}	D_{4t}	D^*_{4t}	D^*_{5t}	D_{5t}	D_{6t}	D_{7t}	D_{8t}

AN ASSESSMENT OF CURRENT METHODOLOGIES

A general ranking of the current baseline estimation methodologies and their associated numerical estimates was performed on the basis of a series of resource allocation experiments which are summarized in Section 3.2 and described in detail in Appendix A of this summary report. These twenty

[4] All of the various sources of information presented in this table are identified in Footnote 159 on page 119 of the summary report.

experiments were designed to assess the acceptability and robustness of each of the baseline estimation methodologies in terms of the following parameters:

- $\hat{\beta}_{i,1970}$ which represents the percentage of the Outlays n.e.c. (not elsewhere classified) component of the Soviet National Income Accounts that is believed to have contained Soviet NSE in 1970--excluding military research, development, test, and evaluation (RDT&E) expenditures;
- $\hat{\alpha}_{it}$ which represents the percentage of RDT&E expenditures which is believed to be of a military nature; and
- $\hat{\omega}_{1970}$ which represents the hypothesized magnitude of undetected Soviet NSE that must be added to the Soviet GNP for 1970.

On the basis of these experiments, the acceptability and robustness of the baseline methodologies to changes in the experimental conditions were assessed as summarized in Table ii.

Table ii

A General Ranking of the Current Baseline Methodologies for Estimating Soviet National Security Expenditures

General Ranking	Baseline Estimation Methodologies
• Very robust	Production Residual Estimation Technique (Bill Lee's Establishment Basis and Commodity Basis Estimates)
• Moderately robust	FNE and BE Residuals Technique (SIPRI estimates) and the External Information Method (Chinese estimates)
• Slightly robust	Revised Budgetary Technique (Stanley Cohn's State Reserves Basis and Final Demand Basis Estimates) and the Direct Costing Techniques (CIA's estimates)
• Unacceptable	Official Soviet Defense Budget, the Original Budgetary Technique (IISS Estimates), and the National Expenditures Method (French estimates)

ANALYSIS OF THE ECONOMIC BURDEN

An analysis of the economic burden of Soviet NSE was conducted on the basis of a series of resource allocation experiments which are summarized in Section 3.6 and described in detail in Appendix B of this summary report. These sixty-four resource allocation experiments were designed to evaluate the economic burden of the alternative baseline estimates of Soviet NSE by means of:

- A set of generalized disaggregation rules which were formulated for the purpose of distributing the alternative estimates of Soviet NSE among twelve sectors of the Soviet economy; and
- An input-output methodology which was developed for the purpose of estimating the magnitude and structure of Soviet civilian manpower engaged in defense production by economic sector, to include: [5]
  - Introduction of the value of the Soviet capital stock involved in the production of defense goods;
  - Elimination of methodology errors associated with the original sectoral disaggregation of estimated Soviet NSE; and
  - Application of new information provided in Stanley Cohn's sectoral disaggregation of estimated Soviet NSE.

On the basis of these experiments, it was demonstrated that the estimated magnitude and the time trend of the aggregations of Soviet manpower and capital resources utilized in Soviet defense production are crucially dependent upon which baseline estimation technique is applied. But, due to limitations in the current availability of data, the sixty-four resource allocation experiments were applied to only two of the baseline estimation methodologies.[6] However, in order to provide an ex post resource allocation analysis of the estimated composition of Soviet NSE that will be relatively insensitive to the selection of baseline estimation techniques, a more general methodology for evaluating the sectoral disaggregation of estimated Soviet NSE was developed. This more

[5] This methodology is based upon a report by Steven Rosefielde on A Preliminary Net Assessment of the Civilian Labor Force Devoted to the Production of Defense Goods in the United States and the Soviet Union, GE-TEMPO, GE 76 TMP-54B (a draft), October 1977.

[6] These two cases, which involve Bill Lee's and Stanley Cohn's techniques, represent alternative characterizations in that Bill Lee's estimates of the level of Soviet NSE over time reflect an increasing share of the Soviet GNP whereas Stanley Cohn's reflect a constant share.

generalized methodology, which is described in detail in Appendix B, is based upon the incidence pattern concept of sectoral burden ratios among the qualitative resource categories (i.e., skills in the case of the labor resource and durability in the case of the capital resource). The principle upon which this concept is based is that an increasing trend in the estimated sectoral economic burden ratios over time implies a transfer of resources from civilian to defense uses. Therefore, in light of an increasing estimate of Soviet NSE for each sector over time, then an increasing proportion of the labor and capital resources is generally required in most economic sectors in order to sustain the Soviet defense build-up during the period 1966-1971. However, it is possible for resource productivity and supply to increase so rapidly in certain economic sectors that the estimated Soviet economic burden ratios for those sectors would not increase over time. As a consequence, the alternative baseline estimation techniques actually used to estimate the sectoral composition of Soviet NSE could produce a declining economic burden ratio for a particular category of labor skill or capital durability within a given sector. Although the magnitude of these burden ratios will be influenced by the choice of estimation technique, the trend in these economic burden ratios may be insensitive to the particular estimation technique selected. As a result, the perceived existence of a fundamental burden incidence pattern that is common to all of the baseline estimation techniques will permit the formulation of some preliminary resource allocation observations and conclusions. For example, those qualitative resource categories (i.e., labor skills or capital durability) with constant or decreasing sectoral burden ratios, despite an increase in the overall sectoral economic burden ratio, indicate that those resource categories have been more available for the support of civilian production than for defense production. By contrast, those qualitative resource categories upon which the incidence of defense burden is increasing over time actually reflect a transfer of resources from civilian to defense production.

Based upon the foregoing generalized sectoral disaggregation methodology, a fundamental burden incidence pattern was defined for each of the twelve Soviet economic sectors. Subsequently, the sensitivity of each of these incidence patterns was analyzed in light of the following changes in experimental

conditions for each of eight categories of labor and capital resources:[7]

- A change in the assumption that all technological progress appears in the final demand, where fewer inputs are required over time in order to obtain a unit of final product;
- Elimination of the special sectoral pattern of RDT&E expenditures from the estimates of Soviet NSE by sector; and
- A test of the importance of performing the burden ratio computations with input-output data in producer's prices, instead of in purchaser's prices.

The relative sensitivity of each of the Soviet economic sectors to the postulated changes in experimental conditions with reference to the various categories of labor and capital resources is defined as follows:

- Very sensitive, which reflects a non-increasing trend in the burden ratio for all of the baseline estimation techniques in more than one resource category;
- Moderately sensitive, which reflects a non-increasing trend in the burden ratio for all of the baseline estimation techniques in at least one resource category;
- Slightly sensitive, which reflects a non-increasing trend in the burden ratio for some, but not all, of the baseline estimation techniques in at least one resource category; and
- Not sensitive, which reflects an increasing trend in the burden ratio for all of the baseline estimation techniques and all resource categories.

The results of the sensitivity analyses from the standpoint of those Soviet economic sectors that have realized the greatest impact of increased Soviet NSE during the period 1966-1971 are summarized in Table iii.

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[7] These changes in experimental conditions are defined in Table B-35 of Appendix B and actually constitute eight different experimental conditions. The eight categories of labor and capital resources are defined in Table B-36 of Appendix B and range from aggregate labor and capital to high-skilled, middle-skilled, and low-skilled labor and to high-durability, middle-durability, and low-durability capital. The eight experimental conditions combined with the eight resource categories constitute the sixty-four resource allocation experiments previously cited.

Table iii

A Relative Ranking of the Soviet Economic Sectors from the Standpoint of Soviet National Security Expenditures (1966-1971)

Relative Ranking	Resource Categories	
	Labor	Capital
• Very Sensitive	Construction Materials (Sector 6) Trade & Distribution (Sector 12)	Agriculture (Sector 1) Light Industry (Sector 9) Construction (Sector 10)
• Moderately Sensitive	Fuels (Sector 2) Chemicals (Sector 7) Food (Sector 8) Light Industry (Sector 9) Construction (Sector 10)	Construction Materials (Sector 6) Chemicals (Sector 7) Food (Sector 8)
• Slightly Sensitive	Machine-Building & Metalworking (Sectors 4 and 5) Transportation and Communication (Sector 11)	Fuels (Sector 2) Machine-Building & Metalworking (Sectors 4 and 5) Transportation and Communication (Sector 11) Trade and Distribution (Sector 12)
• Not Sensitive	Agriculture (Sector 1) Metals (Sector 3)	Metals (Sector 3)

On the basis of the relative rankings reflected in Table iii, some preliminary observations and conclusions with regard to Soviet NSE by economic sectors are as follows:

- The Metals, Machine-Building, Metalworking, and Transportation and Communication sectors, which are identified as Not Sensitive and Slightly Sensitive in Table iii, appear to have absorbed most of the burden of increased NSE in terms of both labor and capital resources during the period 1966-1971; while
- The remaining eight economic sectors, which are identified as Moderately Sensitive or Very Sensitive in Table iii, appear to have generally avoided the burden of increased NSE with reference to one or more of the experimental conditions and the two baseline estimation techniques that have been thus far evaluated.

These preliminary resource allocation conclusions are subject to revision as data which will satisfy the disaggregation rules previously cited are obtained for the other baseline estimation techniques.

APPLICATION OF ECONOMETRIC MODELS

This summary report also provides a review and assessment of the following three well-known econometric models of the Soviet economy from the standpoint of illustrating the primary and secondary ex ante resource allocation effects associated with twelve ex ante resource allocation experiments which are summarized in Section 3.6 and described in detail in Appendix C:[8]

- The Bergendorff-Strangert Model,
- The Niwa Model, and
- The Stanford Research Institute (SRI)-Wharton Econometric Forecasting Associates (WEFA) Soviet Econometric Model (SOVMOD III).

The three alternative resource allocation rules, which define the basic experimental designs for evaluating the impact of resource allocation associated with a given rate of growth in Soviet NSE, may be summarized as follows:

- Investment is exogenous, and Consumption is endogenously determined as a residual (i.e., Consumption versus defense spending);
- Consumption is exogenous, and Investment is endogenously determined as a residual (i.e., GNP versus defense spending); and
- Both Consumption and Investment are endogenously determined, and their shares of nondefense gross national product (GNP) are provided exogenously (i.e., Consumption and Investment versus defense spending).

Within each experimental design, the following four sensitivity analyses experiments may be illustrated:

- The production function for the Industrial sector is changed from Cobb-Douglas to a Constant Elasticity of Substitution (CES) in order to examine the consequences of an elasticity of substitution between capital and labor which is less than unity when the given rate of growth in Soviet NSE changes;

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8 A primary ex ante resource allocation effect is associated with the change in projected level of Soviet NSE when all other factors are held constant, whereas a secondary ex ante resource allocation effect is associated with a change in some other experimental factor with no change in the projected level of Soviet NSE.

- The technological progress parameter of the industrial sector is changed in order to examine the consequences of improved managerial performance or the importation of foreign technology when the given rate of growth in Soviet NSE changes;
- The defense share of Soviet GNP (i.e., the burden ratio) is changed in order to examine the consequences of reducing the percentage of nondefense GNP available for Consumption and Investment when the given rate of growth in Soviet NSE changes; and
- The sectoral composition or mix of Soviet defense final demand between the Industrial and Construction sectors is changed in order to examine the impact upon resource allocation when the given rate of growth in Soviet NSE changes.

The combination of the three alternative sets of allocation rules and four alternative sensitivity analyses constitutes the twelve ex ante resource allocation experiments for the projection of Soviet NSE during the period 1976-1985.

Because the Bergendorff-Strangert model is only designed to examine the resource allocation effects of changing the projected rate of growth of Soviet NSE, it would now be most desirable to conduct these twelve ex post resource allocation experiments utilizing the SRI-WEFA SOVMOD III--which is much better suited for the examination of the resource allocation effects of changing the projected level, or the projected sectoral composition, of Soviet NSE. In other words, changes in the elasticity of substitution among resource inputs and changes in the productivity impact associated with the technology transfer issue may be more effectively isolated in terms of the primary and secondary resource allocation effects associated with alternative estimates of Soviet NSE by means of SOVMOD III than the other models considered.

This summary report provides not only a detailed review of the SRI-WEFA engineering approach to Soviet production, but also insights into such related subjects as:

- The equivalence between Donald Green's ex ante production function in two variables and the more conventional Cobb-Douglas, CES, or Variable Elasticity of Substitution (VES) production function specifications;
- The exact relationship between the parameters used by Professor Karl W. Roskamp of Wayne State University in his VES production function (which contains the CES and Cobb-Douglas specifications as special cases) and the parameters used by Donald Green in his ex ante production function;

- Modification of the original specification of the demand equations for Soviet machinery imports by replacing the détente trend explanatory variable with a compensation agreements explanatory variable; and
- The formulation of a military necessity hypothesis with respect to Soviet trade policies which reflects a greater reliance upon the stock of foreign machinery and equipment than upon the stock of domestic machinery and equipment.

ADDITIONAL RESEARCH

In addition to conducting the foregoing ex ante resource allocation experiments utilizing SOVMOD III, the following experimental and methodological research tasks are recommended:

- Iteration of the twenty ex post resource allocation experiments defined in Appendix A, to include the use of:
  - Bill Lee's National Income Accounts data in current rubles, and
  - The CIA's National Income Accounts data and original definition of Outlays n.e.c.
- Iteration of the sixty-four generalized defense burden experiments defined in Appendix B,
  - Using the general disaggregation rules and CIA estimating technique,
  - Expanding the time period from 1966-1971 to 1960-1975, and
  - Expanding the basic experimental conditions (i.e., technological progress, RDT&E expenditures, and the Leontief Inverse in producer's prices), to include the RAS method of incorporating technological change.
- Empirical implementation of the twelve ex ante resource allocation experiments defined in Appendix C using the SRI-WEFA SOVMOD III model, to include:
  - Changing the form of the production function from Cobb-Douglas to CES and VES,
  - Formal derivation of ex ante VES and CES production functions for the three-variable case wherein capital stock is disaggregated by source of origin (i.e., domestic or imported),
  - Investigation of conditions for exact correspondence between the engineering and the second-order Taylor expansion approaches in the three-variable case, and

- Analysis of a more general elasticity of substitution between the imported and domestic capital stock.

- Implementation of the technological transfer experimental condition in the SRI-WEFA SOVMOD III model using revised import demand equations, to include:
  - Testing alternative specifications,
  - Re-estimation of the ratio of marginal products of imported-to-domestic machinery with the VES production function and the technology transfer impact of "learning by importing",
  - Empirical testing of the military necessity hypothesis, and
  - Extension of the military necessity hypothesis to the import of CMEA (Council of Mutual Economic Assistance) machinery and equipment by the USSR.

- Methodological research involving the utilization of:
  - Statistical data for comparison of the major parameters (e.g., operating budget, military R&D, and procurement) of alternative baseline estimates, to include: the analysis of the statistical relationships among these parameters (as reflected in Section 2.6.1), and
  - Classified data to implement the statistical tests for the base year and growth percentage parameters (as reflected in Section 2.7), and

- Analysis of the possible interdependence of the methodology and information error terms in the alternative estimation techniques over time (as reflected in Section 2.10.2).

FOREWORD

This summary report provides a detailed insight into the highlights and current results of an ongoing research program which is being conducted for the Office of Naval Research (ONR) on The Analysis of Methodologies and Techniques for Estimating Soviet Resource Allocation under the terms of ONR contract N00014-77-C-0676. The program was established by ONR as a result of a workshop, also sponsored by ONR, on Economic Conflict and National Security Research. The report consists of two volumes (i.e., Volume I: Highlights and Current Results and Volume II: Appendices), which contain not only the highlights and current results of the research program, but also a projection of the research to be performed.

In conducting this research program, the General Electric Company Center for Advanced Studies (GE-TEMPO) gratefully acknowledges the guidance and support provided by the Director of the Naval Analysis Program of ONR, Cdr Ronald E. James, and, in particular, Mr. J. Randolph Simpson, who is the Contracting Office Technical Representative (COTR). GE-TEMPO is also particularly appreciative of the information, advice, and assistance provided by the following individuals--all of whom contributed to the preparation of this report:

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Finally, GE-TEMPO wishes to express its heartfelt gratitude to Ms. Carol Ann Costanzo, Senior Secretary of GE-TEMPO's Net Assessment Programs Office, whose devoted, unstinting efforts made possible the production of this report.

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AN ANALYSIS OF METHODOLOGIES AND TECHNIQUES FOR ESTIMATING SOVIET RESOURCE ALLOCATION

1.0 INTRODUCTION

The objectives of the research reflected in this summary report are to characterize and analyze current methodologies and techniques for estimating Soviet resource allocation and to identify and define possible new methodologies and techniques. The need for such research was highlighted during the course of a workshop sponsored by the Office of Naval Research (ONR) on economic conflict. A major topic on the agenda for this workshop was a discussion of the problems involved in estimating Soviet national security expenditures (NSE). The discussion of this topic and the need for further research are reflected in the following extract from the report on the workshop:

> In an effort to determine just how "tight the defense shoe pinches" in the U.S.S.R. and to speculate what this might mean for Soviet priorities and objectives, estimates of the level, the rate of growth, and the share of GNP of Soviet defense expenditures were discussed...Suffice to state that Soviet defense expenditures seem to be growing at a higher rate than previously estimated. To some, this trend suggests the possibility that at a future date, the Soviet Union might resort to "gunboat diplomacy" or military adventurism in order to alleviate its domestic pressures. Others felt that such scenarios are farfetched...Additionally, some participants expressed surprise that significant methodological differences with respect to the various methods of estimating Soviet defense expenditures do exist and have not yet been resolved.[1]

Subsequently, the Office of Naval Research did establish a research program with the basic objective of investigating current and possible new methodologies and techniques for estimating Soviet resource allocation--in particular, Soviet national security expenditures (NSE). This report presents some initial results of the research performed within this program to date and outlines some potential areas of research for the continuation of the program. The need for

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[1] Economic Conflict and National Security Research by Rex D. Minckler and Richard G. Rebh, General Electric Company Center for Advanced Studies (GE-TEMPO), GE 77 TMP-5, Appendix D, page 12, February 22, 1977. In order to provide ready reference to Appendix D of GE 77 TMP-5, it has been reproduced in its entirety as Appendix D of this report.

such research has also been cited in a recent staff study by the Joint Economic Committee of Congress which recommended that "a determination should be made about the merits of the various methods for estimating Soviet defense spending".[2]

1.1 AN OVERVIEW OF THE REPORT

The scope of this report may be briefly summarized as follows:

- An overview providing some background and initial insights into the major sections of the report;
- A review of currently identified methodologies for estimating Soviet NSE and their associated numerical estimates, to include:
  - A discussion of the implications of alternative estimates of Soviet NSE from the standpoint of overall ex post Soviet resource allocation, and
  - A review of the Bergendorff-Strangert Model for purposes of illustrating ex ante trade offs in resource allocation and the introduction of an energy constraint;
- A review of the Stanford Research Institute and Wharton Econometric Forecasting Associates (SRI-WEFA) Econometric Model of the Soviet Union (SOVMOD III) as a proposed research tool for examining:
  - The need for expansion of the production function specification beyond the Cobb-Douglas case,
  - The projected economic burden of Soviet NSE by economic sector incorporating the generalized input-output methodology which is described in Appendix B of this report, and
  - The technology transfer issue and an hypothesis that the Soviet Union imports machinery from the West as a matter of military necessity;
- A summary, with observations and conclusions; and
- A series of appendices containing the more technical information and analyses and a selected bibliography.

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[2] Western Perception of Soviet Economic Trends by Ralph F. Kaufman for the Joint Economic Committee of Congress, March 6, 1978, page 18.

1.1.1 Current Methodologies

Eight methodologies for estimating Soviet NSE may be identified as follows:

- The Official Soviet Defense Budget (i.e., "Soviet estimates");
- The Original Budgetary Technique, i.e., International Institute of Strategic Studies (IISS) estimates;
- The FNE and BE Residuals Technique (i.e., SIPRI estimates);[3]
- The Revised Budgetary Technique (i.e., Stanley Cohn's estimates);
- The Production Residual Estimation Technique (i.e., William T. Lee's estimates);
- The National Expenditure Method (i.e., French estimates);
- The Direct Costing Technique (i.e., CIA estimates); and
- The External Information Method (i.e., Chinese estimates).

In addition, "according to the CIA...England and West Germany have direct-costing efforts of their own underway,"[4] but details with respect to these methodologies are not currently available and are not included in this report. The basic reason for this variety of methodologies is that there are differences among individuals and agencies with respect to their perceptions and interpretations of what actually constitute Soviet national security expenditures.

An initial insight into some of the current methodologies for estimating Soviet NSE was provided during the aforementioned workshop on economic conflict by Mr. John Paisley[5], who observed that:

---

[3] FNE, BE, and SIPRI are abbreviations for the following terms: Financing the National Economy (FNE) component of the USSR State budget, Budgetary Expenditure (BE), and the Stockholm International Peace Research Institute (SIPRI).

[4] Op. Cit., Western Perceptions of Soviet Economic Trends, page 15.

[5] Consultant and former Deputy Director for Strategic Research, Central Intelligence Agency (CIA).

> The first approach is the study of national security outlays through a combination of various forms of Soviet economic statistics and a knowledge of Soviet economic theory and practices. The second approach is the direct costing of known and estimated Soviet military forces, programs, and activities...Over time, this (direct costing) technique was refined and developed into a full matrix of known and estimated cost-generating activities of the Soviet military establishment...Unfortunately, the level of specificity involved in the computations and provided in the output tended to give many users of the data a misplaced confidence in the precision of the results. Several sources of error were possible, such as errors in the:
>
> - Physical size of the forces and their activities,
> - Dollar costs associated with particular weapons or other economic inputs, and
> - Ruble values estimated either directly or indirectly through dollar-to-ruble conversion equations...
>
> Turning now to the budget or statistical data approach, we see that the strengths and weaknesses are inverted. For example, to the extent that one can successfully derive a reasonably confident measure of military expenditures from internal Soviet statistical data, we would have to assume that it represented a fair approximation of how the Soviets view their own outlays for defense. Of course, there is no assurance that a Soviet set of accounts would be translatable directly into the U.S. structure, but one would expect that all major activities would be accounted for. The weaknesses of the budget data approach are basically twofold. First, virtually no definitional detail is possible with this approach. Depending upon the particular technique used, claims may be advanced that operating and maintenance (O&M) costs, and perhaps procurement, can be isolated. Beyond that, there is no way that one can even hope to further disaggregate to the military mission or force level. The second and most telling weakness of the budget or statistical data approach is that the community of reputable and experienced scholars who have worked on this problem do not agree among themselves on the results that it produces.[6]

In light of the problems identified in the foregoing extract, the underlying philosophy of the current research program has been to develop a common frame of reference or "language" by means of which the principles, assumptions, relationships, and techniques associated with the estimation of Soviet NSE may be made more explicit. To this end, the review of the foregoing diverse methodologies in this report will utilize a common frame of

[6] Appendix D, pages D-15 and D-17 to D-19.

reference based upon the major categories of Soviet NSE.

1.1.2 Baseline Estimates

Utilizing these methodologies, a set of baseline estimates of Soviet NSE in current rubles for the period 1960-1975 was generated--a brief overview of which is presented in Table1.0. The obvious differences in the estimated values of Soviet NSE reflect the need for adjustments in the estimates of Soviet GNP, as well as in its major components, such as Consumption, Investment, and non-defense Government spending. The implication of these differences in estimates from the standpoint of overall ex post Soviet resource allocation was reflected in the following observations by Dr. Steven Rosefielde during the workshop on economic conflict:

> When you recapitulate, you want to make sure that you can account for the total allocation of the gross national product in the Soviet Union. Previously, we said "X" share of GNP is investment; "Y" share is consumption; "Z" share is military expenditures; and there's a little residual. Now, we're saying that, in terms of our ruble values of the Soviet gross national product, more is being spent on the military than can be provided by the gross national product. We want to know where it is.....
>
> At a recent seminar in Cambridge, Massachusetts, Mr. Douglas Diamond and some other members of the CIA admitted that 25 billion rubles of Soviet GNP (for 1970) could not be accounted for in Soviet national income accounts due to revision of the estimates of Soviet defense expenditures.....
>
> But, there are two hypotheses. Either there's a much more rapid inflation in defense than elsewhere in the (Soviet) economy, or real defense expenditures have grown much faster than previously supposed...If you look at the physical composition of the procurement, you can postulate very large increases in costs for the same things. An alternative explanation exists, which is that the equipment is getting much more sophisticated.[7]

The distribution of Soviet GNP in the national income account among Consumption, Investment, Defense spending, and non-defense Government spending is essentially an accounting identity--not a behavioral equality. Moreover, it is apparent

[7] Appendix D, pages D-26, D-27, and D-30.

Table 1.0

An Overview of Current Baseline Estimates of Soviet National Security Expenditures (NSE) from 1960-1975 (billions of current rubles)

1	2	3	4	5	6	7	8	9	10	11
				Revised Budgetary Technique (Stanley Cohn Estimates)		Production Residual Estimation Technique (Bill Lee Estimates)				
Year	Official Soviet Defense Budget	Original Budgetary Technique (IISS Estimates)	FNE and BE Residuals Technique (SIPRI Estimates)	State Reserves Basis	Final Demand Basis	Establishment Basis	Commodity Basis	National Expenditures Method (French Estimates)	Direct Costing Technique (CIA Estimates)	External Information Method (Chinese Estimates)
1960	9.3	11.9	17.2	17.3	18.1	16.0	11.8	21.6	22.6	(18.7)
1970	17.9	25.7	38.1	35.4	34.3	46.0	40.2	33.9	42.5	(48.7)
1975	17.4	29.1	54.1	41.8	42.2	71.5	62.3	42.3	58.2	(72.6)
Average Rate of Growth: 1960-1969	6.7%	8.3%	7.9%	7.9%	6.6%	11.0%	13.5%	4.6%	6.5%	10.0%
Average Rate of Growth: 1970-1975	0.0%	2.5%	7.3%	2.8%	4.2%	9.0%	9.1%	4.6%	6.5%	8.3%
Average Rate of Growth: 1960-1975	4.3%	6.1%	7.9%	6.0%	5.8%	10.5%	11.7%	4.6%	6.5%	9.5%
Estimated NSE share of the Soviet GNP for 1960 (184 billion rubles)	.050	.064	.093	.094	.098	.087	.064	.117	.123	.101
Estimate of Soviet NSE	D_{1t}	D_{2t}	D_{3t}	D_{4t}	D^*_{4t}	D^*_{5t}	D_{5t}	D_{6t}	D_{7t}	D_{8t}

that Soviet NSE must be evaluated within the framework of the Soviet national income account. This summary report therefore provides an empirical evaluation of all the baseline estimates within the framework of the Soviet GNP accounting identity from 1970 to 1975.

1.1.3 The Bergendorff-Strangert Model

Another aspect of the analysis of Soviet resource allocation involves the differences in opportunity costs which result from the utilization of alternative methodologies for estimating Soviet NSE. The examination of these differences requires an econometric model and a determination of the behavorial equality of Soviet GNP with its component elements (i.e., Consumption, Investment, Defense and Non-Defense Government spending). In this context, a brief review of the Bergendorff-Strangert Model, which emphasizes the influence that the rate of growth of Soviet NSE exerts upon overall resource allocation, is presented in this report. A more detailed discussion of the various experiments which may be performed with the Bergendorff-Strangert Model is provided in Appendix C, to include the introduction of an energy constraint.

1.1.4 The SRI-WEFA Econometric Model

The workshop on economic conflict also provided a forum for the enunciation of the following hypotheses by William T. Lee with respect to Soviet opportunity costs:

> On the subject of opportunity costs, the hypothesis I would like to offer goes something like this: the opportunity cost of defense expenditures in the Soviet Union is very high because, first of all, there's a fairly direct trade off between defense and investment. There's not much of a trade off between defense and consumption, at least not directly and in the short run. In the longer run, there is a trade off, but in the short run, it's very much defense versus investment.
>
> I would also advance the hypothesis that the rising cost of weaponry is one of the primary causes for the very low pro-

> portion of durables in Soviet investment outlays. In other words, for each new ruble of investment, only about 35 kopecks are allocated to durables; the rest goes into brick and mortar. If you deduct housing and some other things, the ratio is still only about 40 percent. I have seen Soviet explanations of this subject which allege that, in other Western countries, this ratio is much higher...If this is the case and if the low ratio of producer durables in Soviet investment outlays has something to do with defense expenditures, then I would argue that, as a hypothesis, there is a relative shortage of producer durables which adds to the difficulty of substituting capital for labor in the Soviet economy. This situation is evidenced by the relatively modest contribution of technology to the growth of output in Western analyses of the production function of the Soviet economy.
>
> The hypothesis which I would like to suggest...is that the opportunity cost of defense expenditures in the Soviet Union is high because:
>
> - There is a direct trade off between investment and defense and, when you increase defense, it inhibits the growth of investment, and
> - The composition of investment is not conducive to a high growth rate or to the achievement of a high rate of substitution of capital for labor due to the extremely low ratio of producer durables in new investment as a result of the "drainoff" into defense.[8]

The foregoing hypotheses are evaluated in Appendix C of this report, which also suggests the application of the Stanford Research Institute and Wharton Econometric Forecasting Associates (SRI-WEFA) Econometric Model of the Soviet Union (SOVMOD III) as an appropriate tool and controlled environment for analysis and experimentation. In this context,

- Evidence to evaluate the initial hypothesis pertaining to opportunity costs is provided in a recent SRI report to the U.S. Arms Control and Disarmament Agency (ACDA).[9] The necessary generalization of the production function specification from the Cobb-Douglas to the Constant Elasticity of Substitution (CES) form is described in Appendix C, which also proposes that the experiments performed for ACDA by SRI-WEFA be repeated using a new "short run" version of the CES production function which has been recently developed and has a Variable Elasticity of Substitution (VES) form.[10]

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[8] Appendix D, pages D-8 and D-9.

[9] Daniel L. Bond and Donald W. Green, Reanalyzing the Place of National Defense in the Soviet Economy, SSC-TN-5790-1, Stanford Research Institute, July 1977.

[10] Karl W. Roshamp, "A Generalized Production Function for West German Industries," Weltwirtschaftliches Archiv, Band 112, Heft 4, 1976, pages 749-753.

- The other hypothesis pertaining to opportunity cost may be reinterpreted in terms of the "military necessity" of machinery imports from the West in the Soviet production process for the purpose of augmenting the relative shortage of domestic "producer durables". Recent macroeconometric evidence with respect to the significance of machinery imports into the Soviet Union supports this interpretation of the second hypothesis.[11] The methodology required to test this hypothesis is also developed in Appendix C.

1.1.5 Economic Burden Analysis

The report also presents an economic burden analysis of competing uses of Soviet labor and capital resources. This analysis extends the sectoral burden analysis of the Soviet civilian labor force, which was described in a recent draft report,[12] by incorporating new data with regard to labor skills by sector. In addition, the use of average capital utilization coefficients and both fixed and inventory capital stock estimates permits a sectoral burden analysis of the Soviet total stock of sectoral capital resources.[13] A detailed description of this generalized economic burden analysis for Soviet labor and capital resources is provided in Appendix B.

This report terminates with a summary section containing observations, tentative conclusions, and recommendations for future research.

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[11] Donald W. Green and Herbert S. Levine, "Macroeconometric Evidence of the Value of Machinery Imports to the Soviet Union," reproduced in Soviet Science and Technology: Domestic and Foreign Perspectives and edited by J.R. Thomas and U.M. Kruse-Vaucienne, George Washington University, Washington, D.C., 1977, pages 394-412. The military necessity for Soviet acquisition of Western technology through the import of machinery is also highlighted in William E. Odom's article on "The Soviet Military and Foreign Policy" in Survival, November/December 1975, page 278.

[12] Steven Rosefielde, A Preliminary Net Assessment of the Civilian Labor Force Devoted to the Production of Defense Goods in the United States and the Soviet Union, GE-TEMPO draft report, GE 76 TMP-54B, October 1977.

[13] Stanley Cohn, "The Economic Burden of Soviet Defense Outlays," Joint Economic Committee, Economic Performance and the Military Burden in the Soviet Union, 1970, pages 166-188. New data with regard to capital stock durability by sector have been incorporated in the analysis.

2.0 A REVIEW OF CURRENT METHODOLOGIES

As previously indicated, the basic reason for the variety of current methodologies for estimating Soviet NSE is that there are differences among individuals and agencies with respect to their perceptions and interpretations of what actually constitute Soviet national security expenditures. This section of the summary report will review the rationale or philosophy, as well as the fundamental principles, assumptions, and relationships, associated with each of the following methodologies.

- The Official Soviet Defense Budget (i.e., "Soviet estimates"),
- The Original Budgetary Technique (i.e., International Institute of Strategic Studies estimates),
- The FNE (Financing the National Economy) and BE (Budgetary Expenditures) Residuals Technique (i.e., Stockholm International Peace Research Institute estimates),
- The Revised Budgetary Technique (i.e., Stanley Cohn's estimates),[14]
- The Production Residual Estimation Technique (i.e., William T. Lee's estimates),[15]
- The National Expenditure Method (i.e., French estimates),
- The Direct Costing Technique (i.e., CIA estimates), and
- The External Information Method (i.e., Chinese estimates).

2.1 TERMS OF REFERENCE

Soviet defense expenditures may be estimated in rubles or in dollars, or even in some other currency, depending upon the basic reason for estimating NSE in the first place. Again, as explained in the SIPRI Yearbook:

> The main reason for wanting to know the level of a country's military expenditure in local currency--in this case rubles--is that this gives a rough idea of the amount of military activity; that is, it gives an indication of whether the overall size of the military establishment, and the quantity

---

[14] This technique provides two alternative estimates of Soviet NSE based upon the use of two different sources of information for Soviet procurement expenditures (i.e., a State Reserves basis vs a Final Demand basis).

[15] This technique also provides two alternative estimates of Soviet NSE based upon the use of two different sources of information for Soviet production expenditures (i.e., an Establishment basis vs a Commodity basis).

> of resources it absorbs, is rising or falling over time. In addition, it is useful to have an indication of the economic burden of defense in order to be able to assess:
>
> a. the extent to which economic constraints will inhibit an acceleration of military expenditure or maintenance of the existing rate of growth; and
>
> b. the extent to which economic factors may figure in a country's attitude toward the desirability and feasibility of arms control and disarmament.
>
> The reason for wanting to be able to convert the military expenditures of different countries to a common currency--usually dollars--is to permit an estimate to be made of the global diversion of resources to military uses, that is, of the global size of the military establishment.[16]

All estimates of Soviet NSE presented in this report will be expressed in rubles, which is a direct reflection of the importance attached to possible trade offs in Soviet resource allocation and to the economic burden of defense--as was highlighted in the workshop on economic conflict and reflected in Appendix D of this summary report.

Again, for the purposes of this report, the major components of Soviet NSE are identified as shown in Table 2.0. Most of the methodologies discussed in this report are concerned with the estimation of the Usual Components of Soviet military expenditures identified in Section I of Table 2.0. The Additional Components are not generally estimated due to the lack of sufficient information.

The two line items in the Soviet budget which are generally used in all of the methodologies for estimating Soviet NSE are Science and Defense, which appear in Groups II and III, respectively, of the State Budget of the USSR. In most of the methodologies, the numerical estimates are systematically related, in an explicit way, to these two line items of the Soviet budget. Generally speaking, the Defense line item is believed to contain the Operating Budget expenditures (i.e., components 1, 2, and 3 in Table 2.0) and perhaps Military Construction (i.e., component 6 in Table 2.0). The Science line item, on the other hand, is generally believed to contain some, if not all of the Research and

---

16 World Armaments and Disarmament, the Stockholm International Peace Research Institute (SIPRI) Yearbook, the MIT Press, London, England, page 174.

Table 2.0

The Major Components of Soviet National Security Expenditures[17]

I:	Usual Components of Military Expenditures
	1. Pay and allowances of military personnel
	2. Pay of civilian personnel
	3. Operations and maintenance
	4. Procurement
	5. Research and development
	6. Construction
II:	Additional Components of Military Expenditures
	7. Pensions to retired military personnel
	8. Military aid
	9. Civil defense
	10. Paramilitary forces
	11. Military aspects of atomic energy, space, etc.

Development (R&D) expenditures (i.e., component 5 in Table 2.0). Military Procurement expenditures are generally estimated by means of special techniques which uniquely identify each of the methodologies.[18] The Soviet Defense and Science line items of the budget are presented in Table 2.1 for the period 1960-1975.

In discussing the various methodologies, the following generic terms will be used to define:

- An information error--which reflects an insufficient amount of valid sample information, as well as the inclusion of erroneous information with regard to the estimation of Soviet NSE; and
- A methodology error--which reflects the inappropriate use of all available sample information with respect to the estimation of Soviet NSE.

[17] Abraham S. Becker, Military Expenditure Limitation for Arms Control: Problems and Prospects, Ballinger, Cambridge, 1977, Table 2-1, page 13.

[18] The CIA Direct Costing Technique, which appears to be the least dependent upon statistical data in the published Soviet budget, nonetheless uses the Science line item. Moreover, until recently, CIA estimates of the Soviet Operating Budget were very closely correlated with the Defense line item--which establishes an implicit relationship.

Table 2.1

A Chronological Summary of the Defense and Science Line Items of the Official Soviet Budget[19] (in billions of current rubles)

Year	Defense Line Item $(\text{Defense})_t$	Science Line Item $(\text{Science})_t$
1960	9.3	3.9
1961	11.6	4.5
1962	12.6	5.2
1963	13.9	5.8
1964	13.3	6.4
1965	12.8	6.9
1966	13.4	7.5
1967	14.5	8.2
1968	16.7	9.0
1969	17.7	10.0
1970	17.9	11.7
1971	17.9	13.0
1972	17.9	14.4
1973	17.9	15.7
1974	17.7	16.5
1975	17.4	17.5

Within the context of these definitions, the overall impact of an information error may not necessarily be an underestimate of Soviet defense spending due to the presence of erroneous information. Moreover, the overall impact of a methodology error may be either an overestimate or underestimate of Soviet defense spending. If the assumptions and relationships associated with a particular estimating principle are correct, then the methodology is using all of the available sample information in an appropriate manner. On the other hand, if the underlying assumptions and relationships are incorrect, then a methodology error may be said to exist. More technical definitions of an information error in terms of a "sufficient statistic" and of a methodology error in terms of "bias", "consistency", and "minimum variance" will be introduced later in this report.

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19 The figures in this table are based upon the data in Tables E.6 and D.13 on pages 311 and 288, respectively, of William T. Lee's book, The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach, Praeger, New York, 1977.

2.1.2 A Generalization of the Methodologies

A generalization of the eight so-called baseline methodologies may be expressed in terms of the data in Table 2.1 and the following identity:

$$D_{it} \equiv \alpha_{it}(\text{Defense})_t + \beta_{it}(\text{Science})_t + \gamma_{it} + \delta_{it} \qquad (1)$$

where D_{it} is the estimated level of Soviet defense spending, utilizing the ith baseline methodology, and the α_{it}, β_{it}, γ_{it}, and δ_{it} terms relate to the Operating Budget, Military R&D, Procurement, and all other expenditures in Table 2.0, respectively. The δ_{it} parameter will be subsequently associated with a composite error term.

2.2 THE OFFICIAL SOVIET DEFENSE BUDGET

Obviously, the most straight-forward approach to the estimation of Soviet NSE is simply to accept the official defense budget which is published annually by the U.S.S.R.--and this has been identified as the first of the eight methodologies. However, as indicated in the following extract from the SIPRI Yearbook (1974), there is good reason to believe that the official defense budget does not reflect all of the Soviet NSE:

> It is convenient to start by indicating briefly why the subject of Soviet military expenditure has received so much attention, even though a figure for defense expenditure is published annually in the Soviet Union. Perhaps the most persuasive reason is that if the published defense budget is converted to dollars at the official exchange rate, the level of Soviet expenditure relative to that of the United States and other countries is not consistent with other available evidence on the comparative size of their military establishments. For example, in 1972 the dollar equivalent of Soviet military spending on this basis was $21.6 billion, while US spending amounted to $78.2 billion, or roughtly $71 billion if the incremental cost of the Vietnam War is excluded. The difference is so great--almost four-fold--as to cast doubt on the defense budget, on the exchange rate used to convert this to dollars or on both.
>
> In view of these various considerations, it seems reasonable to adopt the working hypothesis that the published defense budget does not cover all expenditures for military purposes.[20]

[20] Op. Cit., the SIPRI Yearbook (1974), pages 172 and 1974.

Application of the generalized identity of Equation (1) to the Official Soviet Defense Budget is based upon the following assumptions, which may be substituted in (1):

$$\alpha_{1t} = 1 \text{ and } \beta_{1t} = \gamma_{1t} = \delta_{1t} = 0 \text{ for all t time periods.} \qquad (2)$$

Obviously, the results are trivial. However, as previously indicated in the extract from the SIPRI Yearbook, the hypothesis that certain categories of national security expenditures have been systematically excluded from the Defense line item may now be interpreted as a rejection of the assumptions in (2).

2.3 THE ORIGINAL BUDGETARY TECHNIQUE

The second baseline methodology was developed by the London-based International Institute of Strategic Studies (IISS) and is briefly described as follows:

> A crude comparison of Soviet and American defense efforts can be derived by estimating Soviet expenditure and GNP at American dollar prices. This method has as many deficiencies as measuring in roubles, but gives a completely different picture. The table below shows the wide range of estimates of the relative burden of defence that the two methods give.

Soviet Defense Expenditure	Billions[a]				As % of GNP[b]		
	1972	1973	1974	1975	1972	1973	1974
Roubles	23.4	23.8	23.8	26.2	5.7	5.4	5.1
Dollars: official exchange rate	28.2	33.1	31.7	36.4	5.7	5.4	5.1
Dollars: estimated conversion rates	84.4	88.9	96.4	103.8	10.8	10.5	10.6

> [a] The rouble defence expenditure is derived by adding 75 per cent of the All-Union science budget to the official defense budget. The dollar expenditure using estimated conversion rates is the midpoint of a range arrived at by the method described in The Military Balance 1973-4 pp. 8-9, which calculates the Soviet manpower costs at American military wage levels in dollars and converts their non-manpower budgetary costs at a computed rate of $1=0.5 roubles. The 1975 official exchange rate is $1=0.72 roubles.
>
> [b] The Readers' Notes (p. vi) show how the rouble value of Soviet GNP is estimated.
> The figure for the dollar equivalent of Soviet GNP at estimated rates was converted at $1=0.52 roubles. This was derived by adjusting for inflation a conversion rate of $1=0.59, which was estimated in an American study as a suitable rate for 1970 compared with the then ruling official exchange rate of $1=0.9.[21]

[21] International Institute of Strategic Studies, The Military Balance, 1975-1976, page 10.

Application of the generalized identity in Equation (1) to the IISS methodology is based upon the following assumptions, which may be substituted in (1):

$$\alpha_{2t} = 1,\ \beta_{2t} = 2/3 \text{ to } 3/4, \text{ and } \gamma_{2t} = \delta_{2t} = 0 \text{ for all } t \text{ time periods.} \qquad (3)$$

As may be observed, the assumptions in (3) reflect the hypothesis that Soviet military Research and Development expenditures have been transferred from the Defense line item and constitute a percentage of the Science line item. Although there may be some difference of opinion with regard to the magnitude of this percentage (β_{2t}), the Original Budgetary Technique may be characterized in terms of specifying a very systematic relationship between the Defense and Science expenditures in Table 2.1 as reflected in the α_{2t} and β_{2t} parameters. It should be noted that this particular methodology has been utilized by the U.S. Arms Control and Disarmament Agency (ACDA) with $\beta_{2t} = 1/2$ and by Stanley Cohn with $\beta_{2t} = 1$, but these users have subsequently adopted more sophisticated techniques.[22]

2.4 THE FNE AND BE BUDGETARY TECHNIQUE

The third baseline methodology is briefly described by SIPRI as follows:

> Every year the Soviet state budget contains large sums of money that are unitemized or unaccounted for. Given the hypothesis that the defense budget is "incomplete," these residuals have naturally attracted attention as potential sources of military expenditures. The following residuals are generally discussed in this connection:
>
> 1. The budgetary expenditure (BE) residual: for the state budget as a whole, the sum of expenditures under each of the main headings falls short of total outlays.
> 2. The national economy (FNE) residual: the main budget heading "financing the national economy" contains a significant amount of expenditure in addition to that accounted for under the various sub-headings.

[22] For additional details, see World Military Expenditures, 1971, ACDA, Washington, 1972, page 55 and Stanley Cohn's article on the "Economic Burden of Soviet Defense Outlays", Joint Economic Committee Hearings on Economic Performance and the Military Burden in the Soviet Union, Washington, 1970, pages 166-168.

These budget residuals are not all potential military outlays. The known components of the BE residuals are (a) internal security, (b) loan service, and (c) grants to investment banks. Similarly, the FNE residual is used to finance subsidies to agricultural procurement and, in some years, agricultural procurement itself.[23]

A summary of data pertaining to the BE and FNE budget residuals for the period 1960-1975 is presented in Table 2.2. Although there have been attempts to adjust the original BE and FNE residuals for the known nonmilitary components and to obtain "net residuals", they are still not considered to be "precise measures of potential military outlays".[24] However, in order to apply the generalized identity of Equation (1) to this estimating methodology utilizing the original FNE and BE residuals, the following assumptions, which may be substituted in (1), will be made:

$$\alpha_{3t} = 1,\ \beta_{3t} = \delta_{3t} = 0, \text{ and } \gamma_{3t} = \text{the sum of FNE and BE residuals.} \quad (4)$$

By setting $\beta_{3t} = 0$, it is assumed that all Soviet military R&D expenditures are either included explicitly in the budget residuals or are approximately equal to the nonmilitary components included in these residuals. If this assumption is false, then the δ_{3t} parameter must be nonzero in order to maintain the identity in Equation (1). If all Soviet military R&D expenditures exceed the nonmilitary components included in the FNE and BE residuals, δ_{3t} will have a positive value. On the other hand, if they are less than the nonmilitary components, then δ_{3t} will have a negative value. Therefore, within the context of this third baseline methodology, the value of the δ_{it} parameter reflects the quality of the information assumed to be present in the FNE and BE residuals. When the information content is true, then δ_{3t} is zero and there is no information error. However, when an information error does exist, then δ_{3t} will have a nonzero value. A more formal discussion of the information error in terms of a random variable with a mean and variance will be presented later in this summary report. The values for the sum of FNE and BE residuals γ_{3t} are presented in Column 3 of Table 2.2.

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[23] Op. Cit., the SIPRI Yearbook (1974), pages 175-176.

[24] Ibid., page 176. The original BE and FNE residuals are presented in Table 8B.1 of the Yearbook, while the net BE and FNE residuals are presented in Table 8B.2.

Table 2.2

The BE and FNE Budget Residuals and Change in State Reserves[25]
(billions of current rubles)

	1	2	3	4	5	6	7	8
Year	BE Residual	FNE Residual	BE and FNE Residuals (Y_{3t})	Growth in Working Capital and Reserves	Change in Working Capital	Change in Unfinished Construction	Change in Working Capital of Collective Farms	Change in State Reserves (Y_{4t})
1960	3.69	4.17	7.86	12.0	3.8	2.4	-0.20	6.00
1961	3.88	2.57	6.45	17.6	7.4	3.4	0.00	6.80
1962	3.25	4.99	8.34	16.6	7.1	1.3	0.80	7.40
1963	2.27	4.86	7.13	14.1	7.1	0.1	0.00	6.90
1964	3.93	4.70	8.63	20.4	10.1	0.9	1.20	8.20
1965	4.38	7.83	12.21	22.3	4.9	2.5	1.60	13.30
1966	4.70	7.80	12.50	24.5	9.4	2.9	1.10	11.10
1967	2.70	9.70	12.40	27.6	13.5	3.3	3.60	8.20
1968	3.20	11.3	14.50	30.8	11.0	6.0	1.60	12.20
1969	4.60	11.6	16.20	29.4	7.0	6.8	1.20	14.40
1970	4.40	15.8	20.20	33.1	15.3	3.9	1.50	11.60
1971	--	--	22.76*	33.4	11.7	5.4	2.10	14.20
1972	--	--	25.65*	30.1	12.1	7.3	.25*	10.45*
1973	--	--	28.90*	37.4	18.3	1.9	3.65*	13.15*
1974	--	--	32.56*	36.1	15.5	4.6	1.90	14.10
1975	--	--	36.69*	34.6	13.3	5.0	0.70	15.60

[25] Columns 1 and 2 were extracted from the SIPRI Yearbook (1974), Table 8B.1, page 176, as updated by William T. Lee in The Estimation of Soviet Expenditures, 1955-75: An Unconventional Approach, Appendix E, Tables E.5A and E.5B, pages 308-309.

The figures in Column 3 were derived by adding Column 1 to Column 2, with the 1971 to 1975 entries extrapolated by means of a curvilinear projection technique--which is based upon the assumption that the sum of the BE and FNE residuals has a geometric trend from the base year value of 20.20 for 1970 and a rate of growth of 12.1 percent that reflects the average rate of growth for the period 1960-1970. This method of estimation is explained and illustrated in J. Johnson's book on Econometric Methods, 1st edition, 1963, McGraw-Hill, New York, pages 44-47.

Columns 4, 5, 6, 7, and 8 are based upon Stanley H. Cohn's paper on "A Re-Evaluation of Soviet Defense Expenditure Estimates," which was submitted to the Stanford Research Institute in June 1976 and revised in August 1976 as shown in Table 2, page 23, of the Appendix. Column 8 was derived by subtracting Columns 5, 6, and 7 from Column 4. The entries in Columns 7 and 8 designated with an asterisk are mid-points of the original interval estimates.

2.5 THE REVISED BUDGETARY TECHNIQUE

The fourth baseline methodology, which is Professor Stanley Cohn's Revised Budgetary Technique, assumes that all Soviet military R&D expenditures are included in the Science line item. Professor Cohn further explains his estimating methodology for the procurement component of Soviet defense expenditures as follows:

> Turning now to the state budget, it would seem logical to include military accumulation in the form of State Reserves in that portion of the budget where accumulation is financed--"Financing the National Economy" (FNE). Such is indeed the practice...A recent detailed breakdown of the budget identifies specific expenditure articles in the FNE group. Article 32, entitled, "Other Expenditures," is defined to include state material reserves, as well as agricultural procurement subsidies, implementation of foreign trade, regulation of wage reforms, and temporary closing of construction projects.[26] As a proportion of FNE outlays in the 1971-75 period, Article 32 is of major importance with over half of the total, some 228 billion rubles, for the five years.[27]
>
> Since the official national income aggregate which includes increments to State Reserves also includes increases in working capital, and in the volume of unfinished construction, it is necessary to deduct these magnitudes from the published aggregate. In addition, the estimate of increments to working capital published annually in Narodnoe Khoziaistvo excludes such accretions by collective farms, so an estimate for the latter category must also be deducted from the published total. The resulting residual represents an upper limit for military procurements, as the reserves accretion category likely includes items of a non-military nature. In terms of current prices,[28] a relatively flat trend in the early sixties changes to a sharp upward kink in 1965, where it again becomes relatively flat until the early seventies. Since 1971, the trend has again been on a higher plateau.[29]

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26 V.A. Evdokimov, Kontrol za ispolneniem gosudarstvennogo buidzheta SSSR, 1975, page 31.

27 Ibid., page 141.

28 As presented in Column 8, Table 2.2 of this summary report (underlining added for highlighting purposes).

29 Stanley H. Cohn, "A Re-Evaluation of Soviet Defense Expenditure Estimates," revised version, August 1976, pages 2-3.

The original growth of working capital and reserves is reflected in Column 4 of Table 2.2. In addition, the changes in published working capital, in unfinished construction, and in the working capital of collective farms are shown in Columns 5, 6, and 7, respectively, of Table 2.2. Therefore, the State Reserves residual, which Stanley Cohn represents as "an upper limit for military procurements," is reflected in Column 8 of the same table, after subtracting Columns 5, 6, and 7 from Column 4.

Application of the generalized identity in Equation (1) to Professor Cohn's Revised Budgetary Technique is based upon the following assumptions, which may be substituted in (1);

$$\alpha_{4t} = 1,\ \beta_{4t} = 1/2,\ \delta_{4t} = 0, \text{ and } \gamma_{4t} = \text{the change in State Reserves.} \qquad (5)$$

With reference to the β parameter, it should be noted that Stanley Cohn has revised his estimate from 1, as indicated in Section 2.3, to 1/2 and does use supplementary information with regard to the change in State Reserves for estimating the γ_{4t} parameter. More specifically, values for the change in State Reserves (γ_{4t}) may be compared to the sum of the FNE and BE residuals (γ_{3t}) in Table 2.2. Inasmuch as the latter sum is not available from published sources beyond 1970, then the curvilinear projection technique previously described in Footnote 25 is used to obtain the entries for the period 1971-1975. These values, which are presented in the lower portion of Column 3 of Table 2.2, are reasonably close to Stanley Cohn's changes in value of the State Reserves in Column 8 of Table 2.2 for the period 1960-1965. However, from 1966 to 1969, the sum of the BE and FNE residuals systematically exceed the changes in value of the State Reserves, with an especially large difference in 1970. Therefore, the assumption in (5) that Soviet military R&D expenditures are included in the Science line item (i.e., $\beta_{4t} = 1/2$) and <u>not</u> in the change in value of the State Reserves can be compared to the assumption in (4) that Soviet military R&D expenditures are included in the sum of the FNE and BE residuals. In brief, there is a significant difference in the two estimating methodologies which are generalized in terms of the different assumptions expressed in (4) and (5).

2.5.1 Alternative Interpretations

As cited in Footnote 25, William T. Lee has presented an alternate interpretation of the data in Table 2.2 which Stanley Cohn used to estimate the change in State Reserves (γ_{4t}) in (5). According to Bill Lee,

> Evdokimov defined Article 32, "other expenditures," which account for more than 50 percent of FNE outlays in 1971-75, as including State material reserves, carrying on (osushchestvlenie) foreign trade, regulating (uporiadochenie) wage reforms, agricultural procurement price subsidies, and temporary closing of construction projects. The specification of State Reserves as falling under Article 32 is new information, although it has long been known that State Reserves were financed from FNE and are not in working capital, the budget contribution to which is financed from Articles 28 and 29.
>
> Exclusion of State Reserves from working capital is more inferential and may be disputed by some Western students. Most working capital is financed from ministerial/khozraschet enterprise funds which the State budget supplements on a small scale. Similarly, most repair funds are from nonbudget sources, but some budget supplement is required. Budget institutions, however, presumably get all their working-capital and repair funds from budget grants under Articles 28 and 29. The existence of these articles for working-capital grants, distinct from State Reserves under Article 32, indicates the two categories are separate, at least for budget purposes. Furthermore, this author has been unable to find any evidence that the TSU includes State Reserves in its working-capital accounts as published in the N.Kh. handbooks.
>
> Recall that Soviet sources cited by Nove and Zauberman located some, perhaps all, procurement in State Reserves in the national income accounts. Evdokimov's allocation of FNE appropriations definitely puts procurement in budget appropriations to State Reserves.[30]

In this context, it would appear that Stanley Cohn believes that the working-capital accounts, as published in Narodnoe Khoziaistvo (i.e., the N.Kh. handbooks), include State Reserves--despite Bill Lee's skepticism. More recently, Stanley Cohn has provided the following assessment of his own estimating methodology:

> The absence of a published, official Soviet estimate of total defense expenditures has led to attempts to estimate such a magnitude from other available economic data. The author (Stanley Cohn) has attempted two such substitute approaches in previous contributions to the Stanford Research Institute and the Joint Economic Committee of Congress. The first approach (see Footnote 13) since disavowed, attempted to fit all defense

[30] Op. Cit., William T. Lee's book on The Estimation of Soviet Defense Expenditures, page 330 (underlining added for highlighting purposes).

outlays, into the framework of the official budgetary appropriation for defense. The second approach was more selective in that the defense budget was no longer assumed to cover the bulk of defense expenditures. Instead it was assumed that the "State Reserves" residual in the national accounts category "Increase in material working capital and reserves" was assumed to be the equivalent of military procurement expenditures. Personnel outlays were separately estimated from military pay, allowances, and strength estimates. The budgetary outlays for defense were assumed to finance both personnel and current operational expenditures. Research and developmental outlays were estimated as before from budgetary and other outlays for "science". Although it is methodologically superior to the first approach, the second one leaves considerable margin for improvement. The identity between State Reserves accretions and military procurement has not been convincingly demonstrated. The assumption that current operational outlays may be approximated by deducting computed personnel costs from budgeted defense outlays yields a time trend at variance with estimated trends in the inventory of military hardware and in personnel strength. The simplifying assumption that an unchanging 50 percent of overall expenditures for "science" comprise military R&D expenditures reqires further investigation.[31]

As may be observed, Professor Cohn's remarks can be interpreted as a suggestion with regard to the need to replace the $\alpha_{4t} = 1$ and $\beta_{4t} = 1/2$ assumptions in (5) with more general specifications. In this context, Stanley Cohn has developed an alternative estimating technique for Soviet military procurement spending which he explains as follows:[32]

The central premise of this approach is that it is possible to estimate the value of military machinery production by deducting the value of consumer durables, producer durables, and net machinery exports from final demand for the output of the machine building industries. In symbols:

[31] Stanley H. Cohn, "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," a revised submission to the Stanford Research Institute, August 1977, pages 1-2 (underlining added for highlighting purposes). An empirical investigation and evaluation of Stanley Cohn's simplifying assumption that $\beta_{4t} = 1/2$ (i.e., "an unchanging 50 percent of overall expenditures for 'science' comprise military R&D expenditures") is conducted later in this summary report.

[32] Ibid., pages 2-3. In the reconstruction of the official input-output (I-O) tables by Professor Vladimir Treml and his team, machine building consists of sectors 15-36 and industry, m.e.c., sector 64 in the 1959 I-O tables; sectors 15-36 and sector 68 in the 1966 I-O tables; and sectors 9-22 and sector 50 of the 1972 I-O tables. The 1966 I-O tables appear in The Reconstructed 1966 Soviet Input-Output Table in Purchasers' and Producers' Prices by the Foreign Demographic Analysis Division of the Department of Commerce, as revised in June 1977.

(i): $MB = D_c + D_p + (D_e - D_i) + D_m$

(ii): $D_m = MB - (D_c + D_p + D_e - D_i)$

where:

MB = Final demand for output of machine building industries,

D_c = Final demand for consumer durables,

D_p = Final demand for producer durables,

D_e = Exports of machinery,

D_i = Imports of machinery, and

D_m = Final demand for Soviet military durables.

The process of obtaining consistent sets of estimates is more complicated than the straight forward equation implies, especially if current value estimates are desired. Both conceptual and methodological questions arise. Although outputs of the machine building sectors comprise the bulk of military procurement, such production is not exhaustive. Such items as missile propellants, gases, and explosives would not be included. For this reason, the final demand control total has been expressed as a range in which the lower limit reflects machine building and the upper limit adds that portion of industrial output which has not been otherwise deconsolidated in the reconstruction of the Soviet input-output tables. The latter magnitude is termed "industry, n.e.c." in the input-output matrices.

Although Professor Cohn's new estimation technique is quite complicated, he is able to produce estimates of Soviet military procurement, γ_{4t}, which are in substantial agreement with the initial estimates shown in Column 8 of Table 2.2. His estimates of the Soviet military procurement of durables are presented in Table 2.3. The data in Table 2.3 may readily be used to implement Stanley Cohn's conceptual formula (ii) in the foregoing explanation. In this context, the estimates of the lower and upper limits of the final demand for military durables (D_m), which appear in Columns 1 and 2 of Table 2.3, also contain the original estimates of the Change in State Reserves provided in Column 6 within these limits--especially for the period 1970-1975. Professor Cohn stresses the importance of his new estimation technique with respect to the original procurement parameters (γ_{4t}) in Column 6 and the new procurement parameters (γ^*_{4t}) in Column 7 of Table 2.3 in the following remarks:

Table 2.3

Estimates of Soviet Procurement of Military Durables by Stanley Cohn [33] (in billions of current rubles)

	1	2	3	4	5	6	7
Year	D_m (lower bound)	D_m (upper bound)	MB (MB FD only)	MB (MB FD Industries, n.e.c.)	$D_c+D_p+D_e-D_i$ (Civilian Final Demand)	Change in State Reserves (Y_{4t})	D_m (midpoint) (Y_{4t}^*)
1960	5.4	8.3	17.0	19.9	11.6	6.0	6.8
1961	5.9	8.9	18.7	21.7	12.8	6.8	7.4
1962	6.4	9.5	20.9	24.0	14.5	7.4	7.9
1963	7.4	10.6	23.0	26.2	15.6	10.1	9.0
1964	6.1	9.1	24.2	27.2	18.1	8.2	7.6
1965	5.7	8.6	25.6	28.5	19.9	13.3	7.1
1966	5.0	7.9	27.6	30.5	22.6	11.1	6.4
1967	5.5	8.8	30.0	33.3	24.5	8.2	7.1
1968	6.4	10.3	32.9	36.8	26.5	12.2	8.3
1969	7.2	11.7	35.7	40.2	28.5	14.4	9.4
1970	7.9	13.1	38.5	43.7	30.6	11.6	10.5
1971	8.3	14.3	41.9	47.9	33.6	14.2	11.3
1972	8.8	15.6	45.2	52.0	36.4	10.4	12.2
1973	10.8	18.2	49.5	56.9	38.7	13.5	14.5
1974	10.4	18.5	53.7	61.8	3.3	14.1	14.4
1975	11.6	20.3	58.2	66.9	46.6	15.6	15.9

[33] Op. Cit., Stanley Cohn, "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data". The column headings of Table 2.3 may be deciphered as follows:

$\overline{\text{MB FD}}$ = final demand for output of machine building industries,
D_c and D_p = final demand for consumer and produced durables, respectively,
D_e and D_i = exports and imports of machinery, respectively,
D_m = final demand for military durables

where the figures in Columns 1 and 2 were derived from Columns 3 and 4 minus Column 5 [i.e., $D_m = MB - (D_c + D_p + D_e - D_i)$] of Table 6, page 19 of the foregoing reference. Columns 3 and 4 were obtained from Columns 3 and 6 of Table 2, page 7 of the foregoing reference, while Column 5 was taken from Column 1 (O.E.R. entries) of Table 5, page 15 of the same reference. Finally, Column 6 is Column 8 of Table 2.2 in this report, and Column 7 is Column 1 plus Column 2 divided by 2.

> Even with all of the qualifications expressed concerning the methodology of a residual computation, there is a surprising similarity with estimates derived by other approaches. Of course, the Lee estimates do follow a similar methodology... The State Reserves residual, as explained at the beginning of the study, is not necessarily equivalent to military procurement. The irregularities in its trend are likely explained by contingency outlays of a non-military nature. If the State Reserves trend line were smoothed, it would not be strikingly different from the final demand residual estimate in the early years. However, the mid-sixties levels are considerably higher and the rate of increase since the mid-sixties much lower.
>
> What is more interesting is the comparison of the final demand residual trend with the procurement estimates of the Office of Strategic Research (OSR), CIA, for the seventies. The OSR trend is flatter and closely parallels the lower residual bound. Its levels of expenditure are quite similar to the upper bound. This similarity is particularly significant, as the OSR estimates are based upon physical estimates of accretions of military durables, initially valued in dollars, they converted to rubles by selected conversion ratios. In other words, the methodologies are independent of one another. Of course, similarity is not sufficient grounds for validity, but at least it indicates that the final demand residual estimates are within ranges of reasonable plausibility.[34]

Professor Cohn's new estimation technique provides an important connecting link with two other baseline methodologies which will be discussed later in this section of the report. As Professor Cohn observes, Bill Lee's Residual Estimation Technique is a similar methodology, but it produces substantially different estimates. Moreover, Stanley Cohn places a great deal of emphasis on the similarity of his estimates of Soviet military procurement with those developed by the CIA. Stanley Cohn's observations illuminate an important methodological point; to wit, his two alternative estimates of Soviet expenditures for military procurement are presented in current rubles, whereas the two alternative estimates provided by Bill Lee in Table 2.4 are presented in constant rubles (i.e., 1967 prices for the commodity basis series and 1970 prices for the establishment basis series). In addition, the CIA estimates are also presented in constant rubles (i.e., 1970 prices). The need to convert all of the alternative baseline estimates to current rubles before a comparative evaluation is conducted is extremely important--in fact, it could reverse the results of the comparative evaluation.

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[34] Ibid., pages 18-20.

2.5.2 Illumination of a Methodological Point

Bill Lee uses the Soviet official MBMW wholesale price index to convert his national security (NS) durables from constant rubles to current rubles.[35] The 1967 and 1970 price indices to be used on Columns 3 and 4, respectively, in Table 2.4 are both declining and are not increasing from the base year. This means that it requires fewer current rubles to have the same purchasing power as the constant ruble estimates shown in Table 2.4. In a recent paper by Robert Leggett and Sheldon Rabin (economists with the Central Intelligence Agency), the CIA estimates in 1970 constant rubles are "adjusted conservatively for a 2% annual rate of inflation" in order to express them in "current rubles".[36] This results in an implicit 1970 price index for use with Column 5 in Table 2.4 that is increasing from the base year. Clearly, such an adjustment requires more, not less, current rubles to have the same purchasing power as the CIA constant ruble estimates in Table 2.4. Therefore, Table 2.4 cannot be cited by Stanley Cohn as evidence of a similarity with CIA's estimates and of a difference with Bill Lee's estimates until an appropriate price index is constructed which will resolve the conflicting information provided by Bill Lee, on the one hand, and by Robert Leggett and Sheldon Rabin, on the other hand. This single index may then be applied to all of the

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[35] Op. Cit., The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach, Table B.10, page 230, as cited in Footnote d of Tables 4.6 and 4.7 on pages 66-67.

[36] Robert E. Leggett and Sheldon T. Rabin, "A Note on the Meaning of the Soviet Defense Budget," September 12, 1977 to be published in Soviet Studies. Although they use the 2% inflation adjustment on the Operating Expenditures, but not on the Procurement Expenditures in the CIA estimates (Table 3, page 15) the implicit 1970 price index constructed is increasing from the base year. The authors cite recent studies which have placed the rate of Soviet price increases at between 1 and 3 percent per year. For example, see David H. Howard, "A Note on Hidden Inflation in the Soviet Union", Soviet Studies, Volumn 28, Number 4, October 1976, pages 599-608 and Gertrude E. Schroeder, "Consumer Goods Availability and Repressed Inflation in the Soviet Union," Economic Aspects of Life in the USSR, NATO-Directorate of Economic Affairs, Brussels, 1975, page 42.

Table 2.4

Comparative Estimates of Military Durables Procurement[37]
(in billions of rubles)

Year	1	2	3	4	5
	Stanley Cohn Final Demand Residual (Current Rubles)	State Reserves (Current Rubles)	William Lee Commodity Basis NS Durables (1967 constant rubles)	William Lee Establishment Basis NS Durables (1970 constant rubles)	CIA OSR Direct-Costing Estimates of Military Procurement (1970 constant rubles)
1966	5.0- 7.9	11.1	4.4- 5.2	7.8- 8.8	
1967	5.5- 8.8	8.2	6.4- 7.4	10.3-11.4	
1968	6.4-10.3	12.2	8.4- 9.5	12.9-14.1	
1969	7.2-11.7	14.4	10.6-11.8	15.5-16.9	
1970	7.9-13.1	11.6	12.3-13.6	17.2-19.2	14.4-16.2
1971	8.3-14.3	14.2	14.8-16.3	20.6-22.3	14.2-16.0
1972	8.8-15.6	10.4	17.7-19.4	24.4-26.3	14.6-16.4
1973	10.8-18.2	13.5	21.4-23.3	28.9-31.0	15.6-17.5
1974	10.4-18.5	14.1	23.6-25.7	32.0-34.4	16.6-18.6
1975	11.6-20.3	15.6	24.8-27.1	34.0-36.7	18.2-20.3

[37] Columns 1, 2, 3, 4, and 5 were obtained directly from Stanley Cohn's "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data", a revised submission to the Stanford Research Institute, August, 1977, Table 6, page 19. The interval estimates in Column 1 are taken from Columns 1 and 2 of Table 4, while the point estimates in Column 2 were obtained from Column 6 of Table 4. The interval estimates in Columns 3 and 4 were originally obtained by Stanley Cohn from a draft copy of W. T. Lee's Soviet Defense Expenditures for 1955-1975, July 31, 1975, Table V-5 (bottom row). Although there have been some revisions in the numerical estimates between this draft copy and his published book, Column 3 may nevertheless be associated with Table 4.7 on page 67, and Column 4 may be associated with Table 4.6 on page 66 of W. T. Lee's The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach. Column 5 is taken from the CIA OSR Estimated Soviet Defense Spending in Rubles, 1970-1975, SR 76-10121U, May 1976, pages 13-15. The text indicates that approximately 36 percent of total defense expenditures of 40-45 billion rubles in 1970 and 50-55 billion in 1975 was used for procurement. Since investment expenditures are 40 percent of total NSE and military construction is 10 percent of total investment outlays, then 40-(.10)40 or (.90)40 = 36 percent of total defense expenditures for weapons procurement. It is to be noted that 4% of the total NSE is for military construction.

baseline estimates in order to convert current ruble estimates to constant ruble estimates and vice versa[38]. Obviously, it is erroneous to inflate the CIA constant ruble estimates to larger current ruble estimates after 1970 and then mechanically compare them to any other current ruble estimates developed by means of various alternative baseline methodologies. Such a mechanical comparison with Bill Lee's current ruble estimates, for example, would ignore the fact that Bill Lee deflates his constant ruble estimates to smaller current ruble values after 1970. Therefore, any reduction in the difference between these two alternative sets of baseline estimates reflects the different price indices used to obtain the current ruble estimates.[39]

2.5.2 Alternative Price Indices

Stanley Cohn's new technique for estimating Soviet expenditures on military procurement requires the construction of an implicit price index, which he explains as follows:

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[38] The current practice of each baseline methodology expressing its numerical estimates in constant or current rubles by means of a different price index should be discouraged. For example, Stanley Cohn argues that since his own adjusted deflator shows approximate parity between 1955 and 1970 procurement prices, he merely assumes that Bill Lee's procurement estimates before 1966 in 1955 prices and after 1966 in 1970 prices are actually "in the same prices". (Op. Cit., Stanley Cohn, "A Re-Evaluation of Soviet Defense Expenditure Estimates," Table 1, Footnote d, page 5.) Bill Lee, on the other hand, uses two separate price indices to deflate his 1955 and 1970 constant ruble estimates, respectively, in order to provide "current ruble" estimates.

[39] For example, if this type of mechanical comparison is applied to Table 3, page 5, of the recent paper by Robert E. Leggett and Sheldon T. Rabin, "A Note on the Meaning of the Soviet Defense Budget", cited in Footnote 36 and Bill Lee's price index is used to convert the CIA constant ruble estimates to current rubles, then the Leggett/Rabin hypothesis would appear to be reasonable for the entire 1960-1975 period instead of only for the 1960-1970 period, as they have argued. The problem lies with the choice of the price index used--not with the Leggett/Rabin hypothesis.

> Although the key control variable is final demand, it is necessary to first derive current price time series for the gross value of machine building output. Current prices are preferred over constant prices, even though the additional step of construction of deflators is required, because military expenditures are measured in current prices and inter-industry transactions are also valued in current terms... Official indexes of machinery production are only published in constant price terms...The official index of gross output in machine building (MB GVO) has been derived from official production indexes times the base year 1966 current price estimate obtained from the reconstructed Soviet input-output table. The reconstructed tables for 1959 and 1972 are also used to obtain current price estimates for those years. The producer rather than the purchasers' prices estimates are used since industrial production is reported in the former prices. If the I-O benchmark output estimates are divided by the constant 1966 price estimates, implicit price changes are obtained. These cannot be construed as real price changes since they incorporate not only true price changes, but also inconsistencies of reporting and methodology among the successive input-output tables and between the I-O tables and estimates of gross production...The official deflator is unsatisfactory (because it has a consistent and marked downward bias).[40] The implicit deflators are in the right directions, but their degrees of change are suspect. Since the I-O benchmark estimates are the key magnitudes in this study, the implicit deflators are accepted with their deficiencies.
>
> For the interim years between and beyond the benchmark years, it is assumed that implicit price changes are of equal annual proportions (i.e., have a curvilinear trend). Derivation of an implicit price index on this assumption enables estimation of a current price (MB GVO) output time series.[41]

These alternative price indices and a new composite price index are presented in Table 2.5.

[40] Ibid., page 10. Stanley Cohn argues that the available, official Soviet wholesale price index for the output of the machinery and metal-working sectors is considered to be inappropriate by both Western and Soviet scholars. Among the various sources cited in Footnote 6, page 10, of the same reference, is Abraham Becker's Ruble Price Levels and Dollar-Ruble Ratios of Soviet Machinery in the 1960s (R-1063-DDRE), Rand Corporation, 1973. It should be emphasized that Bill Lee uses the official Soviet MBMW wholesale price index to convert his constant ruble estimates to current ruble estimates.

[41] Op. Cit., Stanley H. Cohn, "Estimation of Military Durables Procurement Expenditures from the Machinery Production and Sales Data," pages 3-5.

Table 2.5

Alternative Price Indices for Converting Constant Rubles to Current Rubles[42]

	1	2	3	4
Year	William Lee (Official Soviet MBMW Price Index)	Leggett/Rabin (2% Hidden Inflation Price Index)	Stanley Conn (I-O Benchmark Implicit Price Index)	Composite Price Index (Hidden Inflation Offset for the Downward Bias in the MBMW Price Index)
1960	112	82	103.5	105.9
1961	112	84	102.5	105.3
1962	112	85	102.0	104.7
1963	110	87	101.5	104.1
1964	107	89	101.0	103.5
1965	105	91	100.5	102.9
1966	102	92	100.0	102.3
1967	102	94	98.4	101.7
1968	102	96	96.8	101.2
1969	100	98	95.3	100.6
1970	100	100	93.7	100.0
1971	92	102	92.2	97.5
1972	92	104	90.8	95.2
1973	87	106	89.3	92.9
1974	85	108	87.9	90.6
1975	85	110	86.5	88.4
Inflation or deflation rate (1960-1970)	$r_1 = -.011$ (deflation)	$r_2 = .020$ (inflation)	(1960-1966) $r_3 = -.005$ (deflation)	$r_4=(.83)r_1+(.17)r_2=-.006$ (deflation)
Inflation or deflation rate (1960-1970)	$r_1 = -.033$ (deflation)	$r_2 = .020$ (inflation)	(1966-1975) $r_3 = -.016$ (deflation)	$r_4=(.83)r_1+(.17)r_2=-.024$ (deflation)

[42] Column 1 is taken from William Lee's The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach, Table 8.10, page 230. Column 2 is based upon Robert E. Leggett's and Sheldon T. Rabin's "A Note on the Meaning of the Soviet Defense Budget", page 14. The formula for converting the hidden inflation rate ($r_2 = .020$) to a price index is: $(100)(1+r_2)^{t-1970}$ for t = 1960, 1961,..., 1975. Column 3 is based on Stanley Conn's "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data", Table 1, page 4. This index is extremely sensitivie to the 1966 MB GVO control value of 47.9 reported by Stanley Cohn. If the alternative value of 42.1 originally reported by Bill Lee were used in the same way, then the 1972 index value would be 103.4 in Column 3, and the 1966 to 1975 period would be characterized by inflation. Column 4 is based upon the use of the hidden inflation rates in Column 2 to offset the downward bias suspected in the values of Column 1 by combining the rates and using the following formula: $(100)(1+r_4)^{t-1970}$ for t = 1960, 1961,..., 1975 where $r_4 = -.006$ for $1960 \leq t \leq 1970$ and $r_4 = -.024$ for $1970 \leq t \leq 1975$. Inasmuch as approximately 17 percent of total MB final demand constitutes consumer durables, then r_2 is weighted by this percentage when combined with r_1 to estimate r_4.

Bill Lee's price index shown in Column 1 of Table 2.5 is based upon official Soviet sources and is said to have "a consistent and marked downward bias". By contrast, the "hidden inflation" price index, which is advocated by Robert Leggett and Shelton Rabin and is shown in Column 2, is based largely upon evidence of "repressed inflation of Soviet consumer goods". However, since only about one-sixth of total MB final demand constitutes consumer durables, then some importance must be attached to the producer and military durables components of the machine building output--which is reflected to some degree in the official Soviet MBMW price index. Therefore, a composite price index, which reflects both the hidden inflation information in Column 2 and the official Soviet MBMW price index in Column 1, is constructed in Column 4 with 1970 as the base year. This composite price index reflects the much milder "deflation" during the 1960-1975 period is also reflected in Column 3, rather than the more severe "deflation" during this same period that is reflected in Column 1. Finally, Stanley Cohn's implicit price index in Column 3 can be used to convert Bill Lee's estimates of the commodity basis Soviet procurement in Column 3 of Table 2.4 from 1967 constant rubles to current rubles. By contrast, the Robert Leggett and Sheldon Rabin hidden inflation price index in Column 2 can be used to convert the CIA direct-costing estimates of procurement in Column 5 of Table 2.4 from 1970 constant rubles to current rubles. These computations are summarized in Table 2.6, and a comparative evaluation may now be performed which will have strong implications for Stanley Cohn's previous observations.

TABLE 2.6

Another Comparison of the Estimates of the Procurement of Military Durables[43]
(in billions of current rubles)

	1	2	3	4
Year	Stanley Cohn Final Demand Residual	State Reserves	William Lee Commodity Basis NS Durables	CIA OSR Direct-Costing Estimates of Procurement
1966	5.0- 7.9	11.1	4.4- 5.2	
1967	5.5- 8.8	8.2	6.3- 7.3	
1968	6.4-10.3	12.2	8.1- 9.2	
1969	7.2-11.7	14.4	10.1-11.2	
1970	7.9-13.1	11.6	11.5-12.7	14.4-16.2
1971	8.3-14.3	14.2	13.6-15.0	14.5-16.3
1972	8.8-15.6	10.4	16.1-17.6	15.2-17.1
1973	10.8-18.2	13.5	19.1-20.8	16.5-18.6
1974	10.4-18.5	14.1	20.7-22.6	17.9-20.1
1975	11.6-20.3	15.6	21.4-23.4	20.0-22.3

[43] Columns 1 and 2 correspond to Columns 1 and 2 of Table 2.4. Column 3 is Column 3 of Table 2.5 times Column 3 of Table 2.4. Column 4 is Column 2 of Table 2.5 times Column 5 of Table 2.4.

The estimates of the establishment basis Soviet procurement by Bill Lee in Column 4 of Table 2.4 are not included in Table 2.6 for the following reasons, as stated by Stanley Cohn:

> Production estimates and indexes, GVO, for the machine building industry are calculated by the Central Statistical Commission (Ts.S.U.) by aggregating production reports for each enterprise. These enterprise estimates are then aggregated by T.S.U. into principle sector estimates with the sector classification determined by the principal product of the enterprise. This accounting procedure is termed the establishment basis.
>
> Input-output estimates, by contrast, are also based on enterprise reports, but the industrial sector classification is in pure commodity terms. If an enterprise produces products of more than one sector, secondary output and inputs are redistributed to their primary production sectors. Hence the term commodity basis is used. Since the concern...is with machinery production, the desired information should be in terms of machinery output, irrespective of where produced. The commodity accounting basis satisfied this requirement. [44]

However, the use of Bill Lee's estimates of the commodity basis Soviet procurement in Column 3 of Table 2.4 (expressed in 1967 constant rubles) will satisfy Stanley Cohn's criticisms. Also, by using Stanley Cohn's own implicit price index from Column 3 of Table 2.5 to convert Bill Lee's estimates to current rubles, these estimates should now be acceptable.[45] If the CIA direct-costing estimates of procurement in Column 5 of Table 2.4 (expressed in 1970 constant rubles) are converted to current rubles by some other price index (e.g., Column 2 of Table 2.5), then the figures in Column 4 of Table 2.6 are the results. As may be observed, Bill Lee's commodity basis estimates from 1970 to 1975 in Column 3 of Table 2.6 are now quite similar to the CIA direct-costing, current ruble estimates in Column 4 of Table 2.6. By contrast with the earlier comparison by Stanley Cohn using the estimates in Table 2.4, a

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[44] Op. Cit., Stanley Cohn, "Estimation of Military Durables Procurement Expenditures from the Machinery Production and Sales Data," page 27. Stanley Cohn argues that since the establishment accounting basis classified relatively inefficient non-machine building establishments as producers of machinery, the higher valuation of input costs thereby obtained would logically yield commensurately higher final estimates. However, such final products would be no higher in a real sense, but only in reflecting higher cost non-machinery sector producers (underlining added for highlighting purposes).

[45] The relationship between constant and current ruble estimates may be expressed as follows: (constant ruble) (price index) = (current ruble) or, conversely, (current ruble)/(price index) = (constant ruble).

selective choice of price index deflators results in a lack of strong similarity between Stanley Cohn's estimates of the final demand residual in Column 1 of Table 2.6 and the CIA estimates in current rubles shown in Column 4 of Table 2.6 This reversal in Stanley Cohn's previous comparative evaluation of the estimates in Table 2.4 reflects the need to use a single price index to convert all of the alternative baseline estimates to current rubles. The erroneous comparison of current with constant ruble estimates in Table 2.4 resulted in Stanley Cohn's original comparative evaluation, which has been previously described. The use of different price indices results in an equally erroneous comparison of the current ruble estimates in Table 2.6 which appears to contradict Stanley Cohn's original comparative evaluation. Obviously, all comparisons must be made in constant rubles with the same base year or in current rubles with a single price index used for conversion. Therefore, the important methodological point illustrated in Tables 2.4 and 2.6 may be tentatively resolved by using the Composite Price Index presented in Column 4 of Table 2.5 for all of the baseline methodologies and their associated numerical estimates.[46]

2.6 THE PRODUCTION RESIDUAL ESTIMATION TECHNIQUE

The fifth baseline methodology is Bill Lee's Production Residual Estimation Technique, which he describes in general terms as follows:

> The methodology...is based entirely on Soviet data...In this approach, several sets of Soviet data are analyzed for their contribution to an approximate composite estimate of Soviet NSE...This unconventional method does not claim one- or two-decimal-place precision but accepts the uncertainties inherent in the imperfect data with which we must work.
>
> In the unconventional approach, Soviet NSE is estimated as the sum of three components: (a) national security durables (roughly but not exactly equivalent to the U.S. definition of procurement...); (b) personnel pay and maintenance, operations and maintenance of the MoD establishments, and military construction; and (c) military RDT&E and space. Each component is estimated from separate sets of Soviet data.

[46] These baseline numerical estimates will cover the period 1960-1975 for which only Bill Lee's establishment basis estimates will satisfy. His commodity basis estimates cover only the 1966-1975 time period, as shown in Tables 2.4 and 2.6. Therefore, it will be necessary to backcast the procurement portion of his commodity basis estimates from 1966 to 1960 in order to include this technique in the final set of baseline methodologies and numerical estimates.

> Military hardware is estimated from published Soviet data on machinery and equipment output and allocation thereof to investment and consumption, and the ratios of final demand to gross output from the 1959 and 1966 input-output (IO) tables, as constructed by U.S. scholars.
>
> Uniformed personnel costs are estimated separately from published Soviet data. But there seems to be no way of independently estimating the pay of the MoD's civilian personnel or the cost of operating and maintaining the MoD establishment. Hence, the non-personnel portion of the "Defense" budget is accepted as a surrogate, admittedly imperfect, for the cost of maintanance, operations, and military construction.
>
> RDT&E and space can be estimated two ways: (a) by calculating an approximate value of the output of prototypes and space hardware and then estimating the other components of R&D; and (b) by summing labor, capital, and material inputs to the RDT&E performing institutions. Owing to the imperfections in the available data, neither method is very satisfactory. On the other hand, the results are more plausible than those derived by accepting demonstrably erroneous estimates based on the reported "Science" expenditures. Only the input approach is used...., since the data, although imperfect, appear to be more reliable.[47]

Application of the generalized identity in Equation (1) to Bill Lee's Production Residual Estimation Technique is more complicated than the mere estimation of the three parameters involved. However, in order to facilitate comparison with the other, simpler baseline methodologies, this conceptual format will be maintained. In this context, the generalization of Bill Lee's technique is based upon the following assumptions, which may also be substituted in (1):

$$\begin{aligned}
&\alpha_{5t} \leq 1 \text{ for } t = 1960,\ldots, 1970 \text{ and } \alpha_{5t} > 1 \text{ for } t = 1971,\ldots, 1975, \\
&\beta_{5t} = 3/4 \text{ to } 3/5 \text{ over the } t = 1960,\ldots, 1975 \text{ period}, \\
&\gamma_{5t} = \text{the military durables residual from Soviet machine-building and metal-working (MBMW) production statistics, and} \\
&\delta_{5t} = 0
\end{aligned} \tag{6}$$

[47] Op. Cit., The Estimation of Soviet Defense Expenditures, 1955-1975: An Unconventional Approach, pages 31-32.

Bill Lee assumes that the Soviet Operating Budget expenditures are included in the Soviet defense appropriations from 1960 to 1970. However, from 1971 to 1975, his estimate of the Operating Budget exceeds the Official Soviet Defense Budget because the Soviet defense appropriations may have been deliberately manipulated for various political reasons. As a result,

> There is, therefore, no satisfactory method of estimating the MoD's nonpersonnel operating costs on the basis of the available data. At best, one can subtract the estimated personnel costs from the reported "Defense" budget. As is demonstrated ...the latter probably has consisted entirely of operating costs and military construction in most, although not all, years since the early 1950s. This does not necessarily mean that all MoD operating and military construction costs are included in "Defense" every year. For example, "Defense" has been constant or declining since 1969 while operating costs must have risen--although construction outlays could have declined. On the other hand, apparently, some procurement costs were returned to "Defense" in 1961 when it suited Khrushchev's political purposes to increase "Defense" in mid-1961. [48]

The Soviet Operating Budget may therefore be disaggregated into the following two major categories:

- Personnel Expenditures (i.e., SIPRI categories 1 and 2), which will be represented by X_t, and
- Nonpersonnel Operating Expenditures (i.e., SIPRI categories 3 and perhaps 6), which will be represented by Y_t.

However, as observed by Stanley Cohn in the following extract, the assumption that Soviet operational expenditures are financed from the Defense Budget is not a comfortable solution:

> Operational outlays are assumed to be financed from the defense appropriation. Thus, they are estimated residually from the explicit defense budget magnitudes after deduction of personnel costs.

[48] Op. Cit., The Estimation of Soviet Defense Expenditures, 1955-1975: An Unconventional Approach, page 278. From 1961 to 1964, Bill Lee's total estimate of the MoD operating costs are actually less than the Soviet "Defense" budget. This reflects his hypothesis that some procurement expenditures were returned to "Defense" in 1961 and not removed again until 1965. In this context, see Table D.5, Footnote d, page 279 of the foregoing reference. During this 1961-1964 period, $\alpha_{5t} < 1$ in Equation (6) and $\alpha_{5t} = 1$ for 1960 and the period 1965-1970.

> However, this simple method is not a comfortable solution... (because) after 1969 the plateau and subsequent decline in explicit defense expenditures in the face of rising personnel costs, a residual calculation of operational expenditures yields a declining trend in both current and constant prices. Such a conclusion is unrealistic, given the rising level of technical sophistication of Soviet military equipment and the increased size of the armed forces.
>
> The attempt to fit the estimation of operational expenditures residually within the defense budget strait jacket depends, if the basic premise be assumed to be correct, on the assumptions used to estimate levels and trends in personnel expenditures with regard to such variables as compositions of defense manpower and levels of their compensation and subsistence. Perhaps a reasonable time series for the operational category could be fitted into the defense budget aggregate through simulation tests involving different assumptions as to the composition of personnel expenditures.[49]

On the basis of the foregoing citations, it is apparent that Bill Lee and Stanley Cohn believe that both personnel and non-personnel costs have been rising during the 1971-1975 period. This implies that the sum of X_t and Y_t must be also rising over the same period, while the $(\text{Defense})_t$ component of Equation (1) has remained virtually constant--which may be verified in Table 2.1. Instead of attempting to fit the various categories of the Operating Budget into the Defense line item through "simulation tests", the positive correlation of X_t and Y_t over the "sample period" 1960-1970 may be used to project Y_t--given values of X_t determined by the particular baseline methodology. Since each baseline methodology (such as those of Stanley Cohn or Bill Lee) involves different assumptions with regard to the composition of personnel expenditures (i.e., X_t), then the significance of the positive correlation observed between X_t and Y_t during the period 1960-1970 may be used to test the significance of the projections of nonpersonnel operating expenditures (i.e., Y_t) from 1971 to 1975.

2.6.1 A New Technique for Estimating the Operating Budget

The foregoing definition of a new technique for estimating the Soviet Operating Budget may be represented as follows:

[49] Op. Cit., "A Re-Evaluation of Soviet Defense Expenditure Estimates", pages 12-13 (underlining added for highlighting purposes).

$$(X_t+Y_t) = a+(b+1)X_t+\varepsilon_t \qquad (7)$$

where $Y_t = a+bX_t+\varepsilon_t$ for t = 1960,..., 1970

and ε is an additive, random disturbance term.

In order to estimate the parameters a and b by the principle of "least squares," the sum of the squared disturbances must be minimized. Moreover, the values of X_t for t = 1971,..., 1975 are used to project Y_t based upon the positive correlation of X_t and Y_t over the sample period 1960-1970, and the projected Operating Budget therefore becomes:

$$(X_t+\hat{Y}_t) = \hat{a}+(\hat{b}+1)X_t \text{ for } t = 1971,\ldots, 1975 \qquad (8)$$

The ratio of Equation (8) over the $(\text{Defense})_t$ component of Equation (1) then provides the following estimation of the α_t parameter:

$$\hat{\alpha}_t = (X_t+\hat{Y}_t)/(\text{Defense})_t \qquad (9)$$

where $\alpha_t = 1$ is the null hypothesis and

$\alpha_t>1$ is the alternate hypothesis to be tested over the t = 1971,..., 1975 period.[50]

It may be shown that the sampling variance of $\hat{\alpha}_t$ is:

$$\text{Var}(\hat{\alpha}_t) = \left[1/(\text{Defense})_t^2\right] \sigma_\varepsilon^2 \left(1 + \frac{1}{n} + \frac{(X_t - \bar{X})^2}{\sum_{i=1960}^{i=1970} (X_i - \bar{X})^2}\right) \qquad (10)$$

[50] In Equation (6), Bill Lee's assumption that $\alpha_{5t} \leq 1$ for t = 1960,..., 1970 and $\alpha_{5t} > 1$ for t = 1971,..., 1975 can be tested by this procedure, although his $\hat{\alpha}_{5t}$ estimates do <u>not</u> correspond to formula (9). In Equation (10), the sample mean is defined as $\bar{X} = \left[\sum_{t=1960}^{t=1970} X_t\right]/11$. A curvilinear estimating equation may also be specified for a comparison with Equation (7), but this type of econometric evaluation is beyond the scope of this summary report.

which may be used to construct a confidence interval for each estimate of the ratio $\hat{a}_t$ in the t = 1971,..., 1975 forecast periods. This new estimating technique therefore provides a systematic procedure for escaping the "defense budget strait jacket" cited by Stanley Cohn in estimating the Operating Budget. It also provides a method for testing these new estimates for statistical significance when they are compared to the Defense Budget.

The application of this new method of estimation may be illustrated by means of the Soviet personnel costs estimated by Bill Lee and Stanley Cohn from 1960 to 1975. These data, along with the corresponding unclassified CIA estimates of the total Operating Budget expenditures, are presented in Table 2.7. However, the following three basic assumptions apply to the CIA estimates in Column 10 of Table 2.7:

- The Soviet Operating Budget is 40 percent of the CIA estimate of Soviet NSE in 1970 as cited in the CIA document: "Estimated Soviet Defense Spending in Rubles, 1970-1975," SR 76-10121U, May 1976, pages 13-16;
- The 1970 base year figure of (.40)(40.0+45.0)/2 = 17.0 can be "backcasted" to 1960 and "forecasted" to 1975 "using a 4-5 percent annual growth rate:; and
- These original CIA estimates in 1970 rubles can be "adjusted conservatively for a 2 percent annual rate of inflation.

As a consequence, the figures in Column 10 are obtained by means of the curvilinear projection equation described in Footnote 25 of Table 2.2 which is consistent with the Robert Leggett and Sheldon Rabin projections in Table 3 of their forthcoming article, which is cited in Footnote 36. It should be noted that Column 2 of Table 2.2 is not only the Official Soviet Defense Budget, but also it represents Stanley Cohn's original estimates of the Operating Budget. A comparison of Column 2 with Column 5 reveals the fact that this new method of estimation has undone the "defense budget straight jacket" cited by Stanley Cohn for the years 1971-1975. The same procedure was applied to Bill Lee's data in Columns 6 and 7 with the new projections for 1971-1975 provided in Column 8. As may be observed, Bill Lee's projected operating budget (X + Y) in Column 8 is somewhat less than Stanley Cohn's revised projections (X + Y) in Column 5 for the period 1971-1975. This may reflect the fact that Bill Lee believes that, as indicated in Footnote 48, some procurement expenditures were

Table 2.7

Application of a New Method for Estimating the Soviet Operating Budget from 1971-1975 [51]
(in billions of current rubles)

1	2	3	4	5	6	7	8	9	10
Year	Official Soviet Defense Budget	Cohn's Personnel Costs (X)	Cohn's Non-Personnel Costs (Y)	Cohn's Operating Budget (X+Y)	Lee's Personnel Costs (X)	Lee's Non-Personnel Costs (Y)	Lee's Operating Budget (X+Y)	Lee's Operating Budget (Original Estimates)	CIA's Operating Budget
1960	9.3	5.1	4.2	9.3	4.1	5.2	9.3	9.3	9.0
1961	11.6	5.3	6.3	11.6	4.3	7.3	11.6	10.1	9.6
1962	12.6	5.3	7.4	12.6	4.5	8.1	12.6	10.7	10.3
1963	13.9	5.1	8.8	13.9	4.8	9.1	13.9	11.4	10.9
1964	13.3	5.3	8.0	13.3	5.1	8.2	13.3	12.1	11.7
1965	12.8	5.2	7.6	12.8	5.6	7.2	12.8	12.8	12.4
1966	13.4	5.5	7.9	13.4	5.9	7.5	13.4	13.4	13.2
1967	14.5	5.8	8.7	14.5	6.1	8.4	14.5	14.5	14.1
1968	16.7	6.2	10.5	16.7	6.7	10.0	16.7	16.7	15.0
1969	17.7	6.7	11.0	17.7	7.0	10.7	17.7	17.7	16.0
1970	17.9	7.1	10.8	17.9	7.4	10.5	17.9	17.9	17.0
1971	17.9	7.3	(12.7)	(20.0)	7.8	(10.1)	(17.9)	19.3	18.1
1972	17.9	7.7	(13.3)	(21.5)	8.2	(11.5)	(19.7)	20.3	19.3
1973	17.9	7.9	(14.3)	(22.2)	8.9	(12.3)	(21.2)	22.1	20.6
1974	17.6	8.3	(15.4)	(23.7)	9.3	(12.7)	(22.0)	23.1	21.9
1975	17.4	8.7	(16.5)	(25.2)	9.7	(13.2)	(22.9)	24.1	23.3

51. Table 8 merely illustrates how this new estimation method can effectively circumvent the "defense budget strait jacket" by means of a well-recognized econometric procedure. The statistical significance of these 1971-1975 projections based upon Equations (8), (9), and (10) are beyond the scope of this summary report, but will be addressed at another time. The sources of the figures in Table 2.7 are as follows:

- Column 2 is from Table 2.1 and constitutes Stanley Cohn's original estimates of the Soviet Operating Budget.
- Column 3 is from Stanley H. Cohn's "A Re-Evaluation of Soviet Defense Expenditure Estimates" (the revised version), August 1976, Appendix Table 1, Column (14).
- Column 4 is obtained by subtracting Column 3 from Column 2 for 1960-1970 and using $Y_t = -7.31+2.74X_t$ for the 1971-1975 projections as determined by a least squares estimating procedure.
- Column 5 is Column 3 plus Column 4.
- Column 6 is from Bill Lee's The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach, 1977, Table D.6, Column 1, page 280.
- Column 7 is obtained by subtracting Column 6 from Column 2 for 1960-1970 and using $Y_t = 1.37+1.17X_t$ for the 1971-1975 projections as determined by a least squares estimating procedure.
- Column 8 is Column 6 plus Column 7.
- Column 9 is also from Bill Lee's book, Table D.6, Column 3, page 280; from 1961 to 1964, Columns 8 and 9 differ as explained in Footnote 48.
- Column 10 is derived from the methodology developed in Tables 2 and 3 of Robert Leggett's and Sheldon Rabin's forthcoming article on "A Note on the Meaning of the Soviet Defense Budget" in Soviet Studies. The curvilinear projection equation for the mid-point values of their interval estimates is: $z_t = (17.0)(1.065)^{t-1970}$ for t = 1960,...., 1975.

included in the figures shown in Column 2 for the period 1961-1964. As a result, the figures presented in Column 7 for the period 1961-1964 may be "too high", if Bill Lee's argument is accepted.[52] In any event, it is interesting to observe that Bill Lee's original estimates of the Operating Budget in Column 9 for the period 1971-1975 lie between his (X + Y) projections in Column 8 and Stanley Cohn's (X + Y) projections in Column 5. Finally, the CIA estimates in Column 10 for the period 1971-1975, which are based upon a direct costing technique, do agree more closely with Bill Lee's (X + Y) projections in Column 8 than with his original estimates in Column 9. Bill Lee's original estimates of the Soviet Operating Budget for the period 1971-1975 in Column 9 are based upon the following formula:

$$(X_t+\hat{Y}_t) = \hat{a}+(\hat{b}+1)X_t \quad \text{for } t = 1971,\ldots, 1975 \tag{11}$$

with $\hat{a} = 0$ and $\hat{b} = 1.48$ determined by a completely arbitrary procedure.

Therefore, they do not reflect the best statistical use of the available sample information.[53] It may therefore be demonstrated that this new method of estimating the Soviet Operating Budget will yield the best possible set of projections from a given set of data, because it is based upon a least squares estimating procedure. Consequently, even if Bill Lee's argument cited in Footnote 48 is correct and the observations used in Column 7 of Table 2.7 are modified by the procedure outlined in Footnote 51, this new method of estimation will yield an alternative set of projections for the period 1971-1975 that are

52 If Bill Lee's argument is correct, then Column 2 minus Column 9 for the period 1960-1970 reflects this "hidden" procurement expenditure, which may be subtracted from the figures in Column 7 for each year before the new estimation method is applied. A statistical test for observational "outliers" in the period 1961-1964 may also be used as described in T. Yamane, Statistics: An Introductory Analysis, Harper and Row, N.Y., 1967, page 415.

53 The $\hat{b} = 1.48$ estimate is based upon the following statement by Bill Lee in his previously cited book; i.e., "For the years 1971-75, nonpersonnel operating expenditures and military construction (i.e., Y_t) simply are estimated as 148 percent of personnel expenditures (i.e., X_t), the average by which the latter exceeded the former from 1968 through 1970". (Table D.5, page 279.) However, in an earlier draft copy of this book (Soviet Defense Expenditures for 1955-1975, July 31, 1975, Table D.5, page D-14), which was circulated to members of the Intelligence Community, Bill Lee stated: "For the years 1971-1975, nonpersonnel operating expenditures and military construction simply are estimated as 170 percent of personnel expenditures, since the latter exceeded the former by more than 70 percent from 1965 through 1970".

statistically superior to those in Column 9. Once a set of data is accepted for the X_t and Y_t variables in Equation (7), then the parameters a and b can be best estimated by a least squares procedure so that Equation (8) will provide the best projections of the Soviet Operating Budget.

2.6.2 Alternative Methodologies for Estimating Soviet Research and Development Expenditures

Bill Lee is generally critical of the estimating procedure wherein Soviet military R&D expenditures are estimated as a percentage of the Science line item shown in Table 2.1 for the following reasons:

> There are a number of reasons that military RDT&E and Space cannot be derived as a share of "Science". First, as is shown by all the evidence already given, "Science" does not include some applied research outlays and much of the cost of prototype development. Second, V. Trapezhnikov indicates that only 25 percent of "Science" expenditures have been spent for military purposes from the 1950s to date. In 1970, this amounts to only about 2.9 to 3.1 billion rubles. Third, V. Puzenov, the head of GKNT's Planning Department, has indicated that at least 50 to 60 percent of "Science" is spent for nonmilitary programs. Fourth, it is simply not plausible that the USSR could either finance its observed military RDT&E and national space program with 25 to 40 percent of "Science" or spend more on civilian RDT&E than on military/space hardware with only 20 to 25 percent of "Science". Finally, at least three Soviet sources have stated that development costs for military hardware are not in "Science". This is consistent both with Trapezhnikov's allocation of 25 percent of "Science" to the military and with the small share of "Science" funds allocated to the MBMW sector where the prototypes and space hardware are designed and fabricated. Since Trapezhnikov appears to be the most official source available on the military/space component of "Science", a more detailed analysis of his data is in order....
>
> In sum, Trapezhnikov is saying that only 25 percent of "Science" has been devoted to military projects over the years; his ruble figure for "Science" either matches the reported "Science" expenditures precisely or is a version that is about 6 to 7 percent (not 28 to 40 percent) higher each year...To be sure, the 75-25 distribution probably is some sort of nominal average about which individual years may vary. But the basic message is clear: "Science" is not the principal, much less the only, source of military/space RDT&E funding in the USSR. [54]

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54 Op. Cit., The Estimation of Soviet Defense Expenditures, 1955-1975: An Unconventional Approach, pages 16-17 (underlining added for highlighting purposes).

Alternatively, Bill Lee's methodology for estimating military R&D expenditures is based upon the summation of the following R&D production inputs:

- Compensation paid to the R&D labor force,
- Materials utilized, and
- The investment in plant, equipment, and training.

From this summation, he then subtracts 75 percent of the "Science" line item, which he considers to be the civilian share of R&D expenditures, and the result represents his estimate of Soviet military R&D expenditures. The application of Bill Lee's methodology is reflected in Table 2.8.

Table 2.8

An Unconventional Approach to the Estimation of Soviet Military R&D Expenditures[55]

1	2	3	4	5	6	7	8	9
Year	Science Line Item $(\text{Science})_t$	R&D Labor Force Compensation	R&D Materials Inputs	R&D VUZy[56] and Investment	Total R&D Expenditures	Civil R&D Expenditures	Military R&D Expenditures	$\hat{\beta}_{5t}$
1960	3.9	1.9	2.4	1.5	5.8	2.9	2.9	.743
1961	4.5	2.3	2.7	1.6	6.6	3.4	3.2	.711
1962	5.2	2.6	3.0	1.9	7.5	3.9	3.6	.692
1963	5.8	2.8	3.4	2.1	8.3	4.4	3.9	.672
1964	6.4	3.1	3.8	2.3	9.2	4.8	4.4	.687
1965	6.9	3.4	4.2	2.3	9.9	5.2	4.7	.681
1966	7.5	3.6	4.6	2.2	10.4	5.6	4.8	.640
1967	8.2	3.9	5.0	2.6	11.5	6.2	5.3	.646
1968	9.0	4.4	5.5	3.1	13.0	6.8	6.2	.688
1969	10.0	4.9	6.0	2.9	13.8	7.5	6.3	.630
1970	11.7	5.3	6.8	4.2	16.3	8.8	7.5	.641
1971	13.0	5.9	7.4	4.5	17.8	9.8	8.0	.615
1972	14.4	6.3	8.2	4.7	19.2	10.8	8.4	.583
1973	15.7	6.9	9.1	5.2	21.2	11.8	9.4	.598
1974	16.5	7.5	9.7	5.4	22.6	12.4	10.2	.618
1975	17.5	8.3	10.6	5.7	24.4	13.1	11.3	.645

[55] The sources of figures presented in Table 2.8 are as follows:

- Column 2 is taken from Table 2.1;
- Column 3 is taken from Bill Lee's book on an unconventional approach, Column 1, Table D.16, page 293;
- Column 4 is taken from Column 2 of the same table, page 293;
- Column 5 is Column 3 plus Column 4 of the same table;
- Column 6 is the sum of Columns 3, 4, and 5 in this table;
- Column 7 is 75% of Column 2;
- Column 8 is Column 6 minus Column 7; and
- Column 9 is Column 8 divided by Column 2.

[56] As defined in Bill Lee's book, VUZy is the Russian abbreviation for higher educational institutions.

However, in the following extract from a recent review of Bill Lee's book, Philip Hanson is quite critical of what he cites as Bill Lee's "misreading of Trapeznikov" (a Soviet source of information):

> In general, one's confidence in Lee's results is weakened--perhaps unfairly--by his cavalier treatment of some of his Soviet sources. I have checked three citations from which Lee seemed to be deriving some rather unexpected information, and found that in each case he was reading into the Soviet text something that was not, in my judgement, there....
>
> The misreading of Trapeznikov (mis-transliterated by Lee throughout as Trapezhnikov--the text is full of uncorrected errors of this kind) is more serious. Lee imputes (pages 16-17 and 294) to Trapeznikov the statement that 25% of an expanded definition of "science" spending (wider than the budgetary "science" appropriation) is for military purposes. An indiscretion of this order in a small-tirazh book published in, say, Georgian is just about conceivable, but in Voprosy ekonomiki? Needless to say, Trapeznikov did not in fact say this. He said, that only 75% of his expanded definition of "science" spending was an input to technical change, and that one reason why not all "science" spending promoted technical change was (in his view) that some of this spending was for military purposes. To be fair to Lee, he does stress the unsatisfactory and provisional nature of his estimate of military RDT&E. On the other hand, the over-interpretation of Trapeznikov is not a trivial point, since he uses it for a crucial step in his estimation of military RDT&E (Appendix D).[57]

The crucial step in Bill Lee's methodology for estimating Soviet military R&D expenditures, which is dependent upon the correct interpretation of Trapeznikov's statements, is Bill's estimation of Civil R&D expenditures in Column 7 of Table 2.8--and this reflects Bill's interpretation that only 25% of the Science line item in Tables 2.1 and 2.8 contains military R&D expenditures.

Equally critical of Bill Lee's unconventional approach for estimating Soviet military R&D expenditures, Professor Stanley Cohn has observed that:

> His (Bill Lee's) methodology has several possible short-comings. He obtains his wage bill by multiplying the RDT&E employment estimates of David Bronson by published average wages in Science. However, the

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[57] Philip Hanson, "Reviews: Estimating Soviet Defense Expenditure," Soviet Studies, Volume XXX, Number 3, July 1978, pages 407-408.

Bronson total includes RDT&E personnel employed in production enterprises.[58] To the extent that their wages are paid out of the receipts of products sold by their enterprises, there is double counting of defense expenditures. Lee's estimate of material inputs into RDT&E activities is based on the official net material product allocation in the consumption account for "material expenditures in scientific institutions and administration". He obtains estimates of such allocations to science by deducting administrative allocations, which he approximates as about half of budget allocations to "Administration". However, the Soviet concept of administration is an ambiguous one. As Gertrude Schroeder has demonstrated,[59] the manpower and budgetary concepts of "Administration" would be considered governmental administrative activities in other economies. There is no reason to believe that the official concept is the same in the national income allocations as it is in manpower and budget estimates where there are prestige reasons for minimizing the size of the administrative apparatus.

If a broader concept of administration is used in the national accounts, then Lee's material allocations to Science are overstated. Finally, he adds to the official investment allocation by asserting that some investment in Science is financed from the F.N.E. portion of the budget, as well as from the Science allocation itself. His estimate of this supplement is notional. Therefore, there exists several possibilities for Lee's overstatement of RDT&E expenditures in his methodology...

At this stage of research development, given the likely overstatement in Lee's estimate, the revised Cohn estimate for RDT&E will be identical to the earlier estimate. Nimitz's findings that about a half of RDT&E expenditures are used for defense purposes are assumed to apply for the entire period under review.[60]

Although Stanley Cohn accepts Nancy Nimitz's estimate that 50 percent of Soviet expenditures for Science are actually for Defense, there was a time, as indicated in Footnote 22, when his estimate was 100 percent. Generally speaking, the CIA and IISS estimate Soviet military R&D expenditures to be approximately two-thirds of the Science line item in the budget. In view of this range of estimates of military R&D expenditures as a percentage of the Science line item (i.e., from 25% to 67%), the difference between the percentage that is believed to constitute military R&D expenditures and the percentage that is actually used for purposes of estimation becomes critically important when it is also assumed that some Soviet

[58] David Bronson, "Scientific and Engineering Manpower in the USSR and Employment in R&D", Soviet Economic Prospects for the Seventies, JEC report, 1973, pages 584-585.

[59] Gertrude Schroeder, "A Critique of Official Statistics on Public Administration in the USSR", The Association for Comparative Economic Studies Bulletin, Spring 1976, pages 23-44.

[60] Op. Cit., Stanley H. Cohn, "A Re-Evaluation of Soviet Defense Expenditure Estimates," pages 14-16. The reference to Nancy Nimitz's findings is a reflection of her report on The Structure of Soviet Outlays on R&D in 1960 and 1968, RAND Corporation (R-1207-DDRE), Chapter III.

of Table 2.5 times Column 3 of Table 2.4. Column 4 is Column 2 of Table 2.5 times Column 5 of Table 2.4.

military R&D expenditures are excluded from the Science line item. This situation may be expressed symbolically as follows for each estimate in Column 8 of Table 2.8:

$$(\text{Military R\&D})_t = \hat{\beta}_{5t}(\text{Science})_t = \beta^*_{5t}(\text{Science})_t + R_t \tag{12}$$

where β^*_{5t} = the 25 percent of "Science" <u>believed</u> to consist of Soviet military R&D expenditures,

R_t = the amount of Soviet military R&D expenditures excluded from Science, and

$\hat{\beta}_{5t}$ = the estimated level of military R&D expenditures divided by the Science line item.

As may be observed in Column 9 of Table 2.8, the estimates of $\hat{\beta}_{5t}$ range from a high of 3/4 to a low of 3/5 during the period 1960-1975. Although the estimates of $\hat{\beta}_{5t}$ declined from 1960 to 1965, the estimates for the period 1967-1975 appear to have stabilized at slightly less than 2/3. In this context, a methodology based upon the use of a "two-thirds of Science rule" for estimating Soviet military R&D expenditures would provide a good approximation of the average value of $\hat{\beta}_{5t}$ in Column 9 of Table 2.8; i.e., $\left(\sum_{t-1960}^{t=1975} \hat{\beta}_{5t}\right)/16. = .655$.

However, instead of using 25% as the magnitude of β^*_{5t} (as interpreted by Bill Lee) and instead of estimating R_t implicitly as Column 6 minus Column 2 in Table 2.8, it is possible to reinterpret Bill Lee's evidence so as to support the following estimating relationship:

$$(\text{Military R\&D})_t = c(\text{Science})_t + \varepsilon^*_t \tag{13}$$

where c is a constant parameter, and

ε^*_t is a "negligibly small" residual.[61]

The meaning of "negligibly small" values for ε^*_t may be formally expressed as a zero mean value and a constant variance; i.e., $E(\varepsilon^*_t) = 0$ and $\text{Var}(\varepsilon^*_t) = \sigma^2_{\varepsilon^*}$. Moreover, since the variance of the least squares estimator for c is the reciprocal of the sample size (n) times the ratio of the variance of ε^*_t divided by the variance

[61] Using the data in Columns 2 and 8 of Table 2.8 and the least squares estimating technique, then $\hat{c} = .638$ where the sum of all $\hat{\varepsilon}^*_t = (\text{Military R\&D})_t - (.638)(\text{Science})_t$ is zero for the period 1960-1975. However, Column 8 does not contain observations--only Bill Lee's estimates of $(\text{Military R\&D})_t$.

of $(\text{Science})_t$ [i.e., $\text{Var}(\hat{c})=(1/n)(\sigma^2_{\varepsilon^*}/\text{Var}(\text{Science})_t]$, then the assumption with respect to "negligibly small residuals" is equivalent to the assumption that this ratio of variances is subtantially less than unity. If so, then $\text{Var}(\hat{c})$ will be small for a given sample size, and there will be a statistically significant correlation between the annual observations for $(\text{Science})_t$ and the unobserved values for $(\text{Military R\&D})_t$ in Equation (13). Under these conditions and assumptions based on the least squares principle of estimation, the Science line item may be used as an acceptable "instrumental variable" in the estimation of Soviet military R&D expenditures.

The foregoing assumptions may be tested by setting Equation (12) equal to Equation (13) so as to obtain:

$$\hat{\beta}_{5t} = c + (\varepsilon^*_t/(\text{Science})_t) \tag{14}$$

where $\hat{\beta}_{5t}$ will stabilize to the constant value c only when the ratio of ε^*_t divided by $(\text{Science})_t$ becomes "negligibly small".

Bill Lee has provided evidence of this stabilization in the values of $\hat{\beta}^*_t$ associated with his baseline methodology for independently estimating total Soviet R&D expenditures in Column 6 of Table 2.8. Although Bill Lee was primarily concerned with the implicit implementation of Equation (12), his evidence may be reinterpreted to support the estimation of the instrumental variable in Equation (13).[62] However, because the true values of $(\text{Military R\&D})_t$ are unknown, this supporting evidence must be used indirectly to examine the stability of $\hat{\beta}_{5t}$ in Equation (14) for sample period 1960-1975. The evidence in Column 9 of Table 2.8 suggests that ε^*_t is a "negligibly small" residual when c is set to a value slightly less than that of the "two-thirds of Science rule". Therefore, another assumption with regard to β^*_{5t} and R_t in Equation (12) [i.e., $\beta^*_{5t} \approx 2/3$ and $R_t \approx 0$, which are generally used by CIA and IISS] will also be consistent with Bill Lee's estimates of Soviet military R&D expenditures.[63] Only Stanley Cohn has adopted an alternative

[62] The expression for Bill Lee's implicit estimation of R_t in Equation (12) is $R_t = (\text{Total R\&D})_t - (\text{Science})_t$ = Column 6 minus Column 2 in Table 2.8.

[63] When $\beta^*_{5t} = 2/3$ and $R_t \approx 0$, then $c = 2/3$ in Equation (14), which is consistent with Bill Lee's expression in Footnote 62. The essential difference between Bill Lee's estimation of Soviet military R&D, on the one hand, and that of CIA and the IISS, on the other hand, involves their hypotheses with regard to whether or not military or civil R&D expenditures are "hidden" in other than the Science line item. However, this is not relevant to the problem of estimating Soviet military R&D expenditures with "Science" as an acceptable "instrumental variable".

assumption with regard to β^*_{5t} and R_t in Equation (12) [i.e., $\beta^*_{5t} = 1/2$ and $R_t \approx 0$], which implies a value of c that is not consistent with Bill Lee's estimates [i.e., $c = \beta^*_{5t} = 1/2$ when $R_t \approx 0$]. In this context, Stanley Cohn's criticism of Bill Lee's methodology warrants additional research for the purpose of verifying that the stabilized values of $\hat{\beta}_{5t}$ in Table 2.8 are not materially changed so that the test in Equation (14) remains valid. However, it would be possible for Stanley Cohn to retain his belief that $\beta^*_{5t} = 1/2$ (i.e., one half of the Science line item contains military R&D expenditures) and to eventually revise his own estimates so that they would be consistent with Bill Lee, CIA and IISS in Equation (14) (i.e., $c \approx 2/3$). This revision would require that Stanley Cohn be willing to assume that some military R&D expenditures have been hidden outside the Science line item (i.e., $R_t > 0$) and that he provide an independent estimating methodology for the remainder (R_t) in Equation (12) so that the pattern of values for $\hat{\beta}_{5t}$ in Equation (14) will stabilize at $c = 2/3$ for the period 1960-1975.[64] The important estimating relationship in Equation (13) simply requires a stable and statistically significant correlation between the Science line item in the Soviet budget and the Soviet military R&D expenditures.

2.6.3 Estimation of National Security Durables

Bill Lee's procedure for estimating national security (NS) or military durables consists of the following basic steps:

- Determine the establishment (or commodity) machine-building and metal-working (MBMW) gross value of output (GVO) as reported by the Soviet Central Statistical Directorate (TSU) or Gosplan;
- Subtract the GVO of the metal-working (MW) and repair sectors, which then
- Equals the GVO of the machine-building (MB) sector;
- Subtract all intermediate products (inter- and intra-industry), which then

[64] For example, Stanley Cohn has cited an unpublished manuscript by Nancy Nimitz (i.e., Comments on William T. Lee's Interpretation of Soviet Science Outlays, an unpublished RAND manuscript, March 1976, page 25) which introduces evidence that total R&D outlays officially omitted from the Science line item constitute no more than 30 percent of the reported expenditures. If Stanley Cohn were willing to assume that half of this 30 percent omitted from the Science line item constitutes military R&D, then the substitution of $R_t = (.15)(\text{Science})_t$ and $\beta^*_{5t} = 1/2$ into Equation (12) would result in a revised estimate of c = .65, which is close to the "two-thirds of Science rule".

- Equals the final demand (FD) of MB;
- Subtract exports, which then
- Equals the domestic FD of MB; and
- Subtract the producer and consumer durables net of imports, which then
- Equals the national security hardware as a residual.[65]

These nine basic steps may be reduced to the following three equations using the symbolic notation previously utilized by Stanley Cohn on page 28:

(i): MB GVO = MBMW GVO - MW and repair GVO

(ii): MB FD = (MB GVO)(RATIO) = (MB GVO) - intermediate products

(iii): $D_m = \text{MB FD} - (D_c + D_p + D_e - D_i)$

where (RATIO) is the (MB FD)/(MB GVO) ratio from the reconstructed 1959 and 1966 Soviet input/output (I/O) tables in producer's prices.

Equation (i) represents the determination of MB GVO by subtracting the GVO of the metal-working and repair sectors from the MBMW GVO. An alternative approach to the estimation of MB GVO is provided through the use of the MB GVO index from the Soviet statistical handbook (Narodnoe Khoziaistvo) and a MB GVO control total for 1959 or 1966 from the reconstructed Soviet I/O tables in producer's prices. This type of a consistency check is performed by Bill Lee on his estimates of commodity and establishment basis MB GVO for the period 1966-1975.[66] However, this same consistency check for the period 1955-1967 is performed only on his estimates of the establishment basis MB GVO[67] due to an alleged inconsistency with his estimates of the commodity basis MB GVO for this earlier period--which Bill Lee describes as follows:

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[65] Op. Cit., Bill Lee's book on an unconventional approach, pages 36-37. The establishment MBMW GVO series consists of all outputs produced by the MBMW sectors, even if they consist of non-MBMW products. The commodity MBMW GVO series consists of all MBMW products regardless of where they are produced.

[66] Ibid., Table A.16, page 189. The control total for the establishment basis MB GVO is derived from Table A.5, page 173, and uses 1970 as the base year. This derivation of the control total for the establishment basis MB GVO contains a substantial "new product pricing bias" which will be discussed later in this summary report.

[67] Ibid., Table A.14, page 186 provides the consistency check for the establishment basis MB GVO for the period 1955-1967.

(Commodity MBMW) GVO for 1955 and 1960 assumes reported 1959 I/O table ratio of 92 percent for commodity to establishment GVO; ratio applied to establishment MBMW GVO in Table 4.1. (MBMW) GVO for 1959 is from Vladimir Treml, Barry L. Kostinsky, and Dimitri M. Gallik, The 1959 Reconstructed Table, FER No. 6 (Washington, D.C.: U.S. Department of Commerce, Bureau of Economic Analysis, February 1975), pages 45-46. Note that it is incompatible with reported establishment (MBMW) GVO in Table 4.1, since 23.9 divided by the reported ratio of 92 percent equals 26.0, as compared to 29.5 billion rubles. Obviously, the coverage of establishment GVO in the 1959 I/O table differs from TSU establishment coverage in Table 4.1, and probably also from the 1966 I/O table. (MBMW) GVO for 1966 represents the reported 88 percent commodity-to-establishment ratio for that year applied to the establishment (MBMW) GVO of Table 4.1.[68]

A recent revision of the 1959 I/O table by Stanley Cohn, based upon a published revision of the 1966 I/O table by Vladimir Treml, Barry L. Kostinsky, and Dimitri M. Gallik, yields a higher control total for MB GVO (i.e., 20.8 billion rubles) in 1959 in producers' prices.[69] This new control total, plus 6.0 billion rubles for MW and repair GVO, equals 26.8 for the commodity basis MBMW GVO which, when divided by the "reported ratio of 92 percent" equals 29.1 billion rubles for the establishment basis MBMW GVO.[70] Therefore, the recent revision in the 1959 and 1966 I/O tables appears to have eliminated the previous incompatibility cited by Bill Lee because 29.1 is very close to the original 29.5 billion rubles for establishment MBMW GVO reported in Bill Lee's Table 4.1.

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68 Ibid., Table 4.2, Footnote a, page 60. The terms in parentheses have been added for clarity, and the Table 4.1 cited by Bill Lee is located on page 56 of his book. Some more recent evidence, which will be discussed later, indicates that the 1966 commodity-to-establishment-basis ratio is higher than 92 percent for 1959--not lower (i.e., 88 percent) as reported by Bill Lee. In fact, the 1966 commodity-to-establishment-basis ratio became closer to unity after the recent revisions of the 1966 I/O table.

69 Op. Cit., Stanley H. Cohn, "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," Appendix A, "Derivation of input-output control totals for 1959 and 1972," pages A1-A2; and the published revision of the 1966 I/O table by the U.S. Department of Commerce Foreign Demographic Analysis Division, (The Reconstructed 1966 Soviet Input-Output Table in Purchasers' and Producers' Prices, revision of June 1977).

70 When this new control total of 20.8 billion rubles for the 1959 MB GVO is used with the MB GVO index reproduced in Table A.15, Column 2, page 187 of Bill Lee's book, the commodity basis MB GVO that is derived for the period 1955-1967 is consistent with the alternative approach based on Equation (i): i.e., MB GVO = MBMW GVO - (MW and repair GVO).

In spite of this reconciliation, Stanley Cohn has expressed his general criticism of Bill Lee's use of the 92 and 88 percent "commodity-to-establishment-basis ratios" in his consistency checks in the following terms:

> According to the estimates of Treml and his associates, the ratio of commodity to establishment production for the MB sector was .92 in 1959. Lee basically uses this ratio for 1959, in addition to impressionistic estimates of reductions in the ratio to around .88 in 1966 and .88 afterward, in order to estimate both GBO and final demand time series in establishment prices.
>
> One major qualification which he disregards is the non-proportional nature of conversion from commodity to establishment bases. All computations of the commodity establishment ratio are in terms of GVO. Since most of the adjustment concerns reallocation of production of intermediate rather than final products, particularly of material inputs, the adjustment ratio is considerably smaller for final products. In fact, for machinery sectors, the final demand estimates may vary little at all in real terms. Final demand estimate have not been calculated in establishment accounting terms by any official statistical organization. Since the establishment accounting basis classifies relatively inefficient non-machine building establishments as producers of machinery, the higher valuation of input costs thereby obtained would logically yield commensurately higher final estimates. However, such final product would be no higher in a real sense, but only in reflecting higher cost non-machinery sector producers. Therefore, the higher military durables final demand residuals which Lee obtains by the establishment accounting basis are specious. Yet, Lee tends to favor the establishment accounting approach, since he has a longer time series for GVO in such terms. However, a commodity series could have been constructed from data obtained from the I/O reconstructions. 71

The reason that Bill Lee emphasized the establishment basis for estimating NS durables instead of the commodity basis can be traced to the original inconsistency which he discovered for the period 1955-1967--as identified in Footnote 68. According to Bill Lee,

> It should be understood........ that a comprehensive estimate of NS hardware cannot be derived from the I/O tables, in part because of the inherent characteristics of I/O tables and in part because of the way the Soviets chose to report the I/O data. After all, the TSU is not about to present State secrets on a silver platter, so to speak, to Western I/O analysts.

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[71] Op. Cit., Stanley H. Cohn, "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," pages 27-28.

> There are three principal reasons that the answer cannot be derived from the I/O tables. First, the individual MBMW industries all produce both military and civilian products. Even the primarily military industries, for which the Soviets did not publish the flows, do not turn out only military products. Conversely, the primarily civilian industries do not turn out only civilian products. Second, FD in the I/O tables is not reported as being distributed between investment, consumption, and defense. Instead, FD from the I/O tables can be distributed only by "public consumption", "private consumption", and "other FD". These categories really tell us nothing about the end-use allocation of MBMW FD. Third, there is reason to believe, although those who have worked with Treml on reconstructing the I/O tables may disagree vigorously, that the adjustment of the I/O tables from establishment to commodity coverage removed much FD allocated to defense from the MBMW sector.[72]

However, as indicated in Footnote 68, the original inconsistency has now been resolved, so that it is now important to determine whether or not Bill Lee still believes that "a comprehensive estimate of NS hardware cannot be derived from the I/O tables". Stanley Cohn, on the other hand, clearly believes that only a commodity basis is relevant for the estimation of NS procurement based upon the I/O tables; as he observes, "establishment accounting basis estimates are specious". In this context, it will be interesting to determine the ratio of commodity-to-establishment production for the MB sector in the producers' prices version of the 1972 I/O table for the purpose of testing Stanley Cohn's criticism of this portion of Bill Lee's methodology.[73]

Returning now to the three equations on page 48, Equation (ii) represents the determination of MB FD by multiplying MB GVO by the ratio of (MB FD)/(MB GVO) from the reconstructed 1959 and 1966 Soviet I/O tables in producers' prices. In order to provide annual values for the (RATIO) parameter in Equation (ii), Bill Lee uses a linear interpolation procedure for the period 1959-1966, but uses the 1966 value of the ratio for the period 1967-1975 which he explains as follows:

72 Op. Cit., William T. Lee's book on an unconventional approach, pages 41-42.

73 Some recent empirical evidence reported by Robert J. Abbott, Estimating Soviet Spending for Military Hardware From Machinebuilding and Metalworking Statistics, CIA working paper, September 1978, page 5 and by James E. Steiner, Inflation in Soviet Industry and Machine-Building and Metal Working (MBMW) 1960-1975, another CIA working paper, July 1978, page 77, indicates that the 1972 commodity-to-establishment-basis ratio actually exceeds unity (i.e., 1.03 to 1.04) in producers' prices.

> A former Soviet economist reports that the FD-to-GVO ratio was somewhat higher in the unpublished, primarily military, MB sectors in the 1966 table than in the published, primarily civilian, MB sectors. This implies a higher degree of vertical integration in the defense industries, which is consistent with other evidence. It is likely, therefore, that the ratio of MB FD to MB GVO for all (commodity) MB in 1966 actually was in the neighborhood of 65 percent.
>
> Although the conventional wisdom expected the ratio of MB FD to MB GVO to decline substantially over any period whatsoever, evidently it has been fairly stable. As Becker points out, FD may have risen as a share of MB GVO since 1966 with the return to administration by centralized ministries. Soviet sources provide some evidence to support Becker's hypothesis.
>
> In view of this evidence the question is whether the ratio of FD to GVO in the MBMW and MB sectors has risen or declined since 1966. The 1972 I/O table should provide a firm checkpoint as soon as it is processed. Some increase in the weight of intermediate products in GVO may have resulted from the sharp price increases in materials in 1967. Meanwhile, extrapolating the 1966 ratio seems plausible as long as the results are analyzed for their sensitivity to extrapolation of the 1959-66 trends in MB.[74]

By contrast, Stanley Cohn uses the revised 1966 I/O data in producers' prices and a methodology involving the projection of trends in the relationships between purchasers' and producers' prices for the key control values of the (RATIO) in 1959, 1966, and 1972. This methodology utilizes a curvilinear interpolation procedure "by assuming equal annual proportional changes" between the foregoing benchmark years.[75] A comparison of the Bill Lee's and Stanley Cohn's estimates of the (RATIO) is provided in Table 2.9 for the period 1955-1975.

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[74] Op. Cit., Bill Lee's book, pages 190-191 (underlining added for highlighting purposes).

[75] Op. Cit., Stanley H. Cohn, "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," Table 2, Footnote b, page 7. For the period 1959-1966, the curvilinear interpolation formula is $(\text{RATIO})_t = \hat{b}^{t-1959}(\text{RATIO})_{1959}$ for $t=1959,\ldots, 1966$ where $\hat{b} = [(\text{RATIO})_{1966}/(\text{RATIO})_{1959}]^{1/7}$ used by Stanley Cohn; and the linear interpolation formula is $(\text{RATIO})_t = \hat{c}\,(t-1959) + (\text{RATIO})_{1959}$ for $t=1959,\ldots, 1966$ where $\hat{c} = [(\text{RATIO})_{1966} - (\text{RATIO})_{1959}]/(1966-1959)$ used by Bill Lee.

Table 2.9

Alternative Estimates of the (MB FD)/(MB GVO) Ratio [76]

1	2	3
Year	Bill Lee Ratio [77] (percent)	Stanley Cohn Ratio (percent)
1955	65.0 to 70.0	81.3
1956	65.0 to 70.0	79.0
1957	67.0 to 69.0	76.8
1958	64.5 to 68.0	74.6
1959	64.2 to 67.2	(72.5) or (15.0/20.8)
1960	63.6 to 66.5	70.4
1961	63.0 to 65.8	68.3
1962	62.5 to 65.0	66.1
1963	61.9 to 64.3	64.0
1964	61.4 to 63.6	61.8
1965	60.8 to 62.9	59.7
1966	60.2 to 62.2	57.6 or (27.6/47.9)
1967	60.2 to 62.2	56.9
1968	60.2 to 62.2	56.1
1969	60.2 to 62.2	55.4
1970	60.2 to 62.2	54.6
1971	60.2 to 62.2	54.8
1972	60.2 to 62.2	(53.0) or (45.2/85.3)
1973	60.2 to 62.2	52.3
1974	60.2 to 62.2	51.5
1975	60.2 to 62.2	50.8

[76] The sources of the figures presented in this table are as follows:

- Column 2 is from Bill Lee's book: Table 4.1, Row 4, page 56 and Table 4.3, Row 4, page 61--based upon data in Table A.17, page 190; and
- Column 3 is from Stanley Cohn's 1977 paper on the estimation of military durables procurement expenditures, Table 2, Column 2, page 7--which includes the cable industry.

[77] The range of values in this column reflects a negative FD in the cable industry for both 1959 and 1966 which, when included, produces the low limit of the range and, when excluded, produces the upper limit.

Clearly, there is an important difference between the Bill Lee estimates of the (RATIO) in Table 2.9 and those associated with Stanley Cohn's methodology. For example, Stanley Cohn estimates the (RATIO) to be slightly higher than Bill Lee's for 1959 and slightly lower than Bill Lee's by the same difference (i.e., about 5 percentage points) for 1966. However, subsequent to 1966, the difference between these two estimates of the ratio of MB FD to MB GVO widens because Stanley Cohn's estimating methodology is based upon evidence from the 1972 Soviet I/O table. This new information suggests that, when compared to Bill Lee's estimate, the ratio of MB FD to MB GVO has declined from 1966 to 1975 by 10 to 12 percentage points. However, Stanley Cohn's estimating methodology is based upon a number of assumptions and the recent upward revision in the estimate of GVO and final demand for machine building in the 1966 I/O table, with a substantial offset by reduced GVO and final demand for the Industry, n.e.c. sector. As Stanley Cohn explains his methodology,

> Since no similar adjustment is contemplated for their 1959 matrix, it will be assumed that the same relative adjustments are appropriate for the derived 1959 control totals...Consistency is maintained between the 1959 and 1966 estimates by assuming that the same percentage changes in both GVO (gross value of output) and final demand calculated for 1966 also apply to 1959. In terms of purchasers' prices the GVO and final demand for machine building (MB) are increased by 15.5 and 25.8 percent, respectively. In producers' prices the increases are 16.3 and 29.0 percent.
>
> However, the 1972 accounts pose an additional problem. The Treml team, which has painstakingly reconstructed the 1959 and 1966 Soviet I/O matrices in both producers' and purchasers' prices, has not yet had sufficient time and information to recalculate their initial 1972 reconstruction in purchasers' prices to a producers' prices basis. Since consistency in this study is required between the benchmark year estimates, it has been necessary to improvise a recalculation in producers' prices.
>
> Essentially the methodology is one of projecting trends in relationships between purchasers' and producers' prices for the key control variables for the years 1959 and 1966 forward to 1972.[78]

---

[78] Ibid., Appendix A, pages A1-A2. However, the appropriateness of Stanley Cohn's assumed relative adjustment in the 1959 control totals has been questioned by Barry Kostinsky of the Foreign Demographic Analysis Division of the Department of Commerce. According to Barry Kostinsky, no similar adjustment is contemplated, necessary, or even approriate for the 1959 I/O table. The underlining in this citation has been added for highlighting purposes.

Since Bill Lee used the old data before the current revisions to estimate his (RATIO) in Table 2.9, the new data and Stanley Cohn's methodological assumptions may be summarized as shown in Table 2.10. The 1966 row in Table 2.10 reflects the recent revision in the 1966 I/O table which caused the magnitude of MB FD and MB GVO to be increased by virtue of a corresponding decrease in the final demand and GVO for the Industry, n.e.c. sector. This change reflects the impact of new, externally supplied information. As previously indicated, Stanley Cohn then assumes that "the same percentage changes in both GVO and final demand calculated for 1966 also apply to 1959". These assumed "mark-up" percentages are reflected in Columns 3 and 6 for producers' and purchasers' prices, respectively.[79] Therefore, the new data for 1959 is obtained by multiplying the previous data in Column 2 by the assumed "mark-up" percentages in Column 3. These new data determine the ratio of producers'-to-purchasers' prices shown in Column 9 for 1959 and 1966. A curvilinear extrapolation of these 1959 and 1966 ratios, as defined in Footnote 75, determines the 1972 ratios, which are shown in parentheses. These ratios are then multiplied by the 1972 figures in Column 7 to provide the estimates for 1972 which are shown in parentheses in Column 4. As may be observed, the values of the (MB FD)/(MB GVO) ratio in Table 2.10 are the same as the benchmark values for 1959, 1966, and 1972 in Table 2.9.

The crucial step in Stanley Cohn's methodology involves his implicit assumption with regard to the entries in Column 7 of Table 2.10 for 1972 which are explained in Footnote 83. Instead of being located in Column 7, these entries should actually be located in Column 5 in lieu of the (?) entries, because only the 1966 I/O table had actually been revised. Instead of projecting the ratio of producers'-to-purchasers' prices in Column 9 to implicitly account for the future revision of the 1972 I/O table, an alternative approach can be developed. If the assumed "mark-up" percentages in Column 6 are multiplied by the (?) entries in Column 5, then alternative values for 1972 MB FD and MB GVO reflecting the future revision of the 1972 I/O table are generated for Column 7.[80]

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79 However, there may be differences in definitions of machinery building between Bill Lee (who includes the abrasives sector) and Stanley Cohn (who excludes the abrasive sector). Stanley Cohn's methodology is based upon new data for 1966 and the sequence of assumptions identified in Table 2.10.

80 The computations are as follows: (52.5){1.258} = 66.045 for 1972 MB FD and (94.0) {1.155} = 108.57 for 1972 MB GVO with the 1972 (RATIO) = .608 instead of .558 as shown in Column 7.

Table 2.10

A Revision of the Basic Control Totals for MB FD and MB GVO [81]

1	2	3	4	5	6	7	8	9
	Producers' Prices			Purchasers' Prices			Ratio of Producers' to Purchasers' Prices	
Year	Old Data (Lee)	(Assumed Mark-Up)[82]	New Data (Cohn)	Old Data (Lee)	(Assumed Mark-Up)[82]	New Data (Cohn)	Lee	Cohn
MB FD								
1959	11.5	⟨1.290⟩	[15.0]	13.04	⟨1.258⟩	[16.4]	.882	[.915]
1966	25.4		27.6			31.2		.885
1972	(??)		(45.2)	(?)		52.5 [83]		(.860)
MB GVO								
1959	17.8	⟨1.163⟩	[20.8]	19.57	⟨1.155⟩	[22.6]	.909	[.916]
1966	42.1		47.9			52.6		.911
1972	(??)		(85.3)	(?)		94.0 [83]		(.907)
MB FD/ MB GVO RATIO								
1959	.646		[.725]	.666		.726		
1966	.603		.576			.593		
1972	(??)		(.530)	(?)		.558 [83]		

[81] The sources of the figures presented in this table are as follows:

- Column 2 is taken from Bill Lee's book, Table A.17, page 190;
- Columns 3 and 4 are taken from Appendix A of Stanley Cohn's paper cited in Footnote 77;
- Column 5 is Column 7 divided by Column 6;
- Columns 6 and 7 are also taken from Appendix A of Stanley Cohn's 1977 paper;
- Column 8 is Column 2 divided by Column 5; and
- Column 9 is Column 4 divided by Column 7.

As may be observed, Column 2 times Column 3 equals Column 4 and Column 5 times Column 6 equals Column 7--which are underlying relationships.

[82] The comment on Stanley Cohn's methodological assumption cited in Footnote 76 could be interpreted as a requirement for the assumed "mark-up" values in Columns 3 and 6 of this table to be unity--which would definitely change Stanley Cohn's results unless other methodological assumptions were introduced.

[83] These entries are actually "old data," but they were used by Stanley Cohn because they are from the 1972 I/O table--which was not used by Bill Lee. When Stanley Cohn prepared his 1977 paper, only the 1966 I/O tables had been revised. Subsequently, in 1978, a new set of unpublished revisions was released and are cited in the two references identified in Footnote 73.

These new values may then be multiplied by the ratio of producers'-to-purchasers' prices in Column 8 to replace the entries in parentheses in Column 4.[84] The resulting new 1972 (RATIO) is .590 instead of .530 in Column 4 and almost equals Bill Lee's 1966 (RATIO) of .603 in Column 2. Consequently, by using an alternative approach based on Stanley Cohn's assumed "mark-up" percentages, instead of projecting trends in relationships between purchasers' and producers' prices, then Bill Lee's assumption of a constant MB FD/MB GVO ratio from 1967 to 1975 is consistent with the same evidence cited by Stanley Cohn. Obviously, the issue of a declining or constant (RATIO) since 1966 has not been resolved by the introduction of Stanley Cohn's new evidence based upon the revised 1966 I/O table. What is needed is the explicit revision of the 1972 I/O table in producers' prices in order to determine the (??) entries in Column 2 of Table 2.10. This explicit evidence is now available, but has not yet been processed. However, it will be the focus of future empirical research which will have as its objective the resolution of the obvious discrepancy between the alternative estimates of (RATIO) in Table 2.9.

Returning once again to the three equations on page 48, Equation (iii) represents the determination of the final demand for military durables based upon the same computational procedure which is illustrated in Table 2.3 (i.e., MB FD minus Civilian Final Demand equals Military Final Demand). However, Stanley Cohn performs all of his calculations in current rubles which requires price index deflations from constant to current rubles to be performed for each component of Equation (iii). By contrast, Bill Lee performs all of his calculations in constant rubles and then performs only one deflation of the Military Final Demand variable, D_m, instead of a separate deflation of each component with different price indices. The methodological problems created by the comparison of two or more baseline methodologies using different price deflators has been previously cited in this report. However, there is one final methodological difference between Stanley Cohn and Bill Lee in their respective implementation of Equation (iii) which Stanley Cohn explains as follows:

[84] The computations are as follows: (66.045)(.882) = 58.25 for 1972 MB FD and (108.57)(.909) = 98.69 for 1972 MB GVO with the 1972 (RATIO) = .590, instead of .530 as shown in Column 4. The use of the ratio value in Column 8 reflects the only known ratio value in Column 9 (i.e., the 1966 value) which has approximately the same magnitude.

Bill Lee underestimates demand for both consumer (D_c) and producer (D_p) durables. In a methodology which relies upon a residual calculation of military demands, such underestimates serve to overstate his military demand estimates.

He bases his time series for consumer durables demand on a production index derived by the Office of Economic Research, C.I.A. in 1963. He then moves this index forward by assuming that its trend is identical to that of his MBMW index. His valuation is in terms of 1967 prices. What he overlooks are the benchmark consumer durables final demands magnitude available from the reconstructed I/O tables. In addition, the O.E.R. has constructed new consumer durables production indices, the most recent one being made available to this author in April of 1977.

Bill Lee also underestimates producer durables demand, largely for methodological reasons. We both use investment durables expenditures as a proxy for producer durables production. However, my study assumes a lag of a year between production and accretion to capital stock, while Lee assumes simultaneity. Since the durables component of fixed investment has exhibited a monotonically rising trend, his absence of a lag introduces a persistent downward bias in his producer durables estimates.[85]

These improvements in the estimation of the variables D_c and D_p tend to reduce the magnitude of the estimates of miltiary durables final demand, D_m. However, the magnitude of MB FD is crucially dependent upon the value of D_m in Equation (iii). This, in turn, depends upon the value of the (RATIO) in Equation (ii)--which has been estimated by both Bill Lee and Stanley Cohn in Table 2.9. The resolution of the different underlying assumptions pertaining to the estimation of the (RATIO) in Table 2.10 will not be possible until the evidence in the revised 1972 I/O table in producers' prices is processed. Since any new MB GVO control total for the 1959 I/O table (i.e., 20.8 in Column 4 of Table 2.10) will resolve the original inconsistency cited by Bill Lee between the establishment and commodity basis MB GVO from Equation (i), one crucial factor in Bill Lee's methodology is the estimation of the (RATIO) in Equation (ii) which Bill Lee acknowledges as follows:

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[85] Op. Cit., Stanley Cohn's 1977 paper, pages 29-30.

> Given the availability of Soviet data, some degree of error in the calculation of NS durables is inevitably introduced at several points...If there has been a substantial decline in the ratio of MB FD to MB GVO since 1966, the low side of the error budget...would imply NSE for 1970 and 1975 (in 1967 prices on a commodity basis) of 1.3 and 8.3 billion rubles less than the original estimates...With the exception of 1975 when uncertainty about the ratio of FD to GVO dominates the calculations, the NS durables' component of MB GVO appears to have been understated by 10 to 20 percent or more in the previous calculations. [86]

In this context, Bill Lee's estimates of the commodity basis NS durables expenditures for 1970 and 1975 shown in Column 3 of Table 2.4 can be reduced by 1.3 and 8.3 billion rubles, respectively. This would be a sufficient adjustment to achieve substantial agreement with Stanley Cohn's estimates of Final Demand Residual in Column 1 and State Reserves in Column 2 of Table 2.4, which would resolve the major methodological difference between Bill Lee's and Stanley Cohn's numerical estimates of Soviet National Security durables. Bill Lee's commodity and establishment basis estimates of Soviet NSE are summarized in Table 2.11.

In order to compare Bill Lee's estimates of Soviet NSE in Table 2.11 with those developed by Stanley Cohn, Stanley Cohn's estimates of Soviet NSE based upon the Change in State Reserves and the Final Demand for Military Durables are summarized in Table 2.12. A comparison of Columns 6 and 7 in Table 2.12 reveals close agreement between these two alternative estimates of Soviet NSE during the period 1960-1975. By contrast, a comparison of Columns 6 and 7 in Table 2.11 reveals an increasing divergence between these two alternative estimates of Soviet NSE after 1970. Inasmuch as the CIA estimate of Soviet defense spending in 1970 is 40-45 billion rubles (excluding Space) and 45 to 50 billion rubles (including Space), then Bill Lee's estimates for 1970, as reflected in Columns 6 and 7 of Table 2.11, are in close agreement. By comparison, Stanley Cohn's estimate of Soviet NSE for 1970, as reflected in Columns 6 and 7 of Table 2.12,

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[86] Op. Cit., Bill Lee's book on an unconventional approach, pages 70-75. The data in Row 4 of Table 4.9 is applied to Table 4.4 in order to compute the reduction in NSE for 1970 and 1975 in 1967 prices on a commodity basis.

Table 2.11

Bill Lee's Estimates of Soviet National Security Expenditures on a Commodity and Establishment Basis [87]

(billions of current rubles)

1	2	3	4	5	6	7
Year	Soviet Operating Budget α_{5t}(Defense)$_t$	Military R&D Expenditures β_{5t}(Science)$_t$	NS Durables (Commodity Basis) Y_{5t}	NS Durables (Establishment Basis) Y^*_{5t}	Soviet NSE Estimates (Commodity Basis) D_{5t}	Soviet NSE Estimates (Establishment Basis) D^*_{5t}
1960	9.3	1.0 (2.9)	(4.3) 1.5*	5.7 (3.8)	11.8*	16.0
1961	10.0	1.1 (3.2)	1.8*	7.3 (5.2)	12.9*	18.5
1962	10.7	1.3 (3.6)	2.2*	9.0 (6.7)	14.2*	21.0
1963	11.4	1.4 (3.9)	2.7*	10.2 (7.7)	15.5*	23.0
1964	12.1	1.6 (4.4)	3.2*	10.8 (8.0)	16.9*	24.5
1965	12.8	1.7 (4.7)	3.8*	11.5 (8.5)	18.3*	26.0
1966	13.4	1.9 (4.8)	4.6	12.7 (9.8)	22.2	28.0
1967	14.5	5.3 [7.1]	6.7	12.7	28.3	32.5
1968	16.7	6.2 [8.1]	8.7	15.6	33.5	38.5
1969	17.7	6.3 [8.4]	10.7	18.0	36.8	42.0
1970	17.9	7.5 [10.0]	12.3	20.6	40.2	46.0
1971	19.3	8.0 [10.6]	13.5	22.7	43.4	50.0
1972	20.3	8.4 [11.3]	16.4	25.8	48.0	54.5
1973	22.1	9.4 [12.6]	18.7	29.0	53.4	60.5
1974	23.1	10.2 [13.6]	20.4	31.7	57.1	65.0
1975	24.1	11.3 [14.9]	23.3	36.1	62.3	71.5

[87] The sources of figures presented in Table 2.11 are as follows:

- Column 2 is Column 9 of Table 2.7.
- Column 3 is Column 8 of Table 2.7 for entries inside the parentheses between 1960 and 1966, and for entries outside the parentheses between 1967 and 1975. The entries outside the paratheses between 1960 and 1966 are military R&D expenditures not concealed in the estimates of NS durables in Columns 4 and 5. The entries inside brackets between 1967 and 1975 reflect estimates of military R&D expenditures such that Columns 2, 3, and 4 will sum to Column 6.
- Column 4 reflects the mid-point values of Table 4.7, page 67 of Bill Lee's book for entries between 1966 and 1975. Entries with asterisks from 1960 to 1965 are "backcasted" from the 1966 base value using the mid-point of Bill Lee's 1959 I/O table estimate for NS durables of 1.25 billion rubles (i.e., Table 4.2, Column 2, Row 9, on page 60 of Bill Lee's book). The revised 1959 I/O table estimate reflecting the new information from Stanley Cohn with regard to MB GVO, but still using Bill Lee's methodological assumptions, is 3.20 billion rubles. The magnitude of the 1960 entry in parentheses (4.3) reflects the new information, and the 1960 entry with an asterisk (1.5) reflects the old information. It may also be observed in Column 3 that, for the year 1960, there would appear to be (2.9-1.0) = 1.9 billion rubles of military R&D concealed in the 4.3 billion ruble estimate of NS durables in Column 4, which leaves 2.4 billion rubles for procurement. But, (2.4-1.5*) = 0.9 billion rubles, which reflects an underestimate of procurement due to the previous inconsistency or "information error" associated with the original Soviet 1959 I/O table. Therefore, each entry with an asterisk from 1960 to 1965 implements the statements in Footnote 46--but based upon the original information available to Bill Lee in the Soviet 1959 I/O table.
- Column 5 is from Tables 4.5 and 4.6, pages 65-66 of Bill Lee's book. Entries within the parentheses from 1960 to 1966 assume no hidden military R&D expenditures, whereas entries outside the parentheses from 1960 to 1966 contain some hidden military R&D expenditures and correspond to the mid-point values in Table 4.5, page 65 of Bill Lee's book. Entries from 1967 to 1975 exceed the mid-point values in Table 4.6 on page 66 because the lower boundary values for military R&D in Column 3 plus Columns 2 and 5 must equal Column 7. The difference between these entries and the mid-point values reflect hidden military R&D expenditures for procurement.
- Column 6 reflects the mid-point values of Table 4.7, page 67 of Bill Lee's book and corresponds to the sum of Columns 2, 3, and 4--simiiar to the foregoing explanation of Column 3.
- Column 7 reflects the mid-point values of Tables 4.5 and 4.6, pages 65-66 of Bill Lee and corresponds to the sum of Columns 2, 3, and 5. The entries without parentheses in Columns 3 and 5 are compatible and may be added.

Table 2.12

Stanley Cohn's Estimates of Soviet National Security Expenditure on Change in State Reserves and Final Demand for Military Durables Bases [88]
(billions of current rubles)

1	2	3	4	5	6	7
Year	Soviet Operating Budget $\alpha_{4t}(\text{Defense})_t$	Military R&D Expenditures $\beta_{4t}(\text{Science})_t$	Change in State Reserves (midpoint) γ_{4t}	Final Demand for Military Durables (midpoint) γ^*_{4t}	Soviet NSE Estimates (Change in State Reserves Basis) D_{4t}	Soviet NSE Estimates (Final Demand for Military Durables Basis) D^*_{4t}
1960	9.3	2.0	6.0	6.8	17.3	18.1
1961	11.6	1.9	6.8	7.4	20.3	20.9
1962	12.6	2.2	7.4	7.9	22.3	22.9
1963	13.9	2.6	10.1	9.0	23.4	25.5
1964	13.3	3.0	8.2	7.6	24.5	23.9
1965	12.8	3.5	13.3	7.1	29.6	23.5
1966	13.4	3.8	11.1	6.4	28.3	23.7
1967	14.5	4.1	8.2	7.1	26.8	25.8
1968	16.7	4.5	12.2	8.3	33.4	29.6
1969	17.7	5.0	14.4	9.4	37.1	32.2
1970	17.9	5.9	11.6	10.5	35.4	34.3
1971	17.9	6.5	14.2	11.3	38.6	35.7
1972	17.9	7.2	10.4	12.2	35.5	37.3
1973	17.9	7.8	13.5	14.5	38.9	40.2
1974	17.6	8.2	14.1	14.4	39.9	40.3
1975	17.4	8.8	15.6	15.9	41.8	42.2

[88] The sources of the figures presented in Table 2.12 are as follows:

- Column 2 is the Soviet Defense line item from Table 2.1;
- Column 3 is 50 percent of the Soviet Science line item from Table 2.1;
- Column 4 is Column 8 of Table 2.2;
- Column 5 is Column 7 of Table 2.3;
- Column 6 is the sum of Columns 2, 3, and 4; and
- Column 7 is the sum of Columns 2, 3, and 5.

are 5-10 billion rubles less than the CIA estimate of 40-45 billion rubles. In 1975, Bill Lee's estimates of Soviet NSE are greater than the CIA estimates, while Stanley Cohn's estimates are still less than the CIA estimates.[89] Any downward revisions in the estimates of D_{5t} and D^*_{5t} in Table 2.11 as a consequence of Stanley Cohn's observations on Bill Lee's methodology will result in a closer agreement with the CIA estimates. By like token, any upward revisions in the estimates of D_{4t} and D^*_{4t} in Table 2.12 as a consequence of Bill Lee's indirect observations on Stanley Cohn's methodology will also result in a closer agreement with the CIA estimates.

2.6.4 Criticisms of the Unconventional Method

As has already been indicated in part, there have been a number of critical observations with regard to Bill Lee's unconventional method of estimating Soviet NSE. However, Bill Lee himself provides the following summary of the basic criticisms of his methodology:

> The CIA, Abraham Becker of RAND, and SRI have been quite critical of this author's method of estimating NS durables as a residual of MBMW GVO. The important criticisms are common to Becker and to CIA, who are joined in some instances by Stanley Cohn for SRI.
>
> The three basic criticisms concern alleged systematic biases in MBMW GVO, namely,
>
> - Double counting of intermediate products and components,
> - Overpricing of new products, and
> - Compatibility of MBMW GVO data from the I/O tables with USSR TSU and Gosplan MBMW GVO.
>
> The CIA has raised all three issues but Becker and Cohn abstain from the double-counting charge.

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89 The CIA estimate of NSE for 1975 is 50-55 billion constant 1970 rubles, which becomes 58-62 billion current rubles when 2 percent per year inflation is assumed. If the broader definition of Soviet NSE (to include Space expenditures) is used, then the 5 billion constant 1970 rubles or 5.5 billion current rubles must be added to the CIA estimate of NSE for 1975.

In summary, first, the double-counting bias is very small and has been removed. Second, none of the empirical evidence supports the overpricing charge. Value added in MBMW grows as rapidly as GVO. Any undetected overpricing is removed along with producer and consumer durables. Third, the identifiable consequence of unavoidably mixing I/O table data with TSU and Gosplan data is to minimize the NS durables estimated as residual of MBMW GVO.

> The new data accepted by the CIA indicate the NSE estimates of this study are conservative: 50 billion compared to 43 to 49.5 billion rubles in 1970 (broad definition of NSE including Space). If the critics had been right, my estimates would have been much too high instead of somewhat too low. The revised CIA estimates for procurement and spare parts in 1970 implicitly admit that the biases alleged by the critics were not present that year.
>
> All the valid criticisms for which adequate data are available have been taken into account. Four valid criticisms remain, but none represent errors of method, fact, or judgment; they are simply defects in the data. When better information becomes available, the necessary adjustments will be made. [90]

Although a rigorous examination of these basic criticisms is beyond the scope of this summary report, a somewhat detailed review of the arguments will be provided in the sub-sections which follow.

2.6.4.1 The Double-Counting Bias. The principal proponent of the double-counting bias criticism is the late Rush Greenslade of CIA, who provided the following empirical evidence in support of his contention that there is such a bias in Soviet reports on MBMW GVO:

> The index of total machinery production shown in the text is derived from the official gross value of output indexes (GVO) for MBMW with adjustments for the double counting and new product pricing biases. It is an attempt to approximate a net output for MBMW, including the production of military hardware.
>
> The upward bias in the GVO measure resulting from increasing double counting of inputs is shown below by changes in the ratio of MBMW deliveries outside the MBMW branch to GVO for the branch as given in the input-output tables for 1959, 1966, and 1972.

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90 Op. Cit., Bill Lee's book on an unconventional approach, pages 150-151 (underlining added for highlighting purposes).

Table 15

Ratio of MBMW Deliveries Net of Intra-Branch Deliveries to MBMW GVO (Purchasers' Prices)

Year	Ratio
1959	.823
1966	.775
1972	.715

The declining trend in the ratio was extrapolated to 1950 at the rate of 0.0015 points per year to 0.837 in 1950. The estimated ratios were multiplied by the values of GVO in current prices for 1950-60 to arrive at an estimated net value of MBMW output. The rate of price inflation was assumed to be one percent per year except in years when the official price index dropped more than five percentage points. In those years, it was assumed that all of the drop was real, except for 2½ percentage points. This assumption, while somewhat arbitrary, is consistent with the general belief that the official price index reflects price movements for only a sample of commodities; excluding for the most part newer products which in the aggregate would reflect an upward trend in prices. This procedure surely does not yield precise results--only plausible trends for illustrative purposes. The resulting machinery index grows at an average annual rate of 12.3 percent per year in 1951-60 compared with 15.7 percent for GVO, a difference of 3.4 percent per year.

For 1961-1966 and 1967-1972, the trend of net output of MBMW in current prices taken from the input-output tables was deflated by the price deflator suggested by Becker.[91] He estimated that machinery prices rose by two percent in the 1960's and one percent in the 1970's...The average discount of the deflated net index from the official gross index is 3.3 or 3.2 (percent per year). These discounts are applied to the official index to obtain adjusted indexes for the intervening years.

For the period 1973-1975, the adjusted rate of growth is assumed to be the official annual rate of growth minus 3.2 percentage points.[92]

---

91 Abraham Becker, Ruble Price Levels and Dollar-Ruble Ratios of Soviet Machinery in the 1960's, RAND report 1063-DDRE, January 1973, page 21.

92 Rush V. Greenslade, "The Real Gross National Product of the USSR, 1950-1975" in the Joint Economic Committee (JEC) of Congress report on Soviet Economy in a New Perspective, October 14, 1976, page 291. An example of double counting is a carburetor that may be counted once as the output of a carburetor plant and again as a portion of the output of a truck factory within the MBMW sector.

Bill Lee, however, dismisses Rush Greenslade's double-counting bias argument and the need to use a "net" MBMW GVO value in step one of the procedure which he describes on page 47 in the following terms:

> His (Greenslade's) evidence for the bias in MBMW is essentially of two kinds: (a) evidence that intra-MBMW intermediate products have increased as a share of GVO and (b) a few samples of branch output reported in rubles that do not match branch GVO. Greenslade did not, however, discuss changes in the ratio of all intermediate products, intra-MBMW and inter-industry, to GVO over time, which conversely, is the ratio of FD to GVO. It is the trend in these latter two ratios, not the trend to intra-MBMW transactions alone, that determines whether the official GVO data are systematically biased upward.
>
> The recently completed reconstruction of the 1959 and 1966 I/O tables in producers' prices appears to be the best empirical test of the alleged "double counting" bias in MBMW GVO. Treml, et al, found that the ratio of MBMW FD to GVO rose from 58 percent in 1959 to 61 percent in 1966, while for MB the ratio declined from 64.2 percent to 60.2 percent, if one includes the negative FD for the cable industry in both I/O tables, and from 67.2 percent to 62.2 percent, if one excludes the cable industry.[93] This means that, between 1959 and 1966 at least, "double counting" bias did not exist in MBMW as a whole and was quite small in MB. To be sure, Treml's data are in current prices, but it is difficult to see how FD could have declined as a share of GVO in constant prices if it increased or declined slightly in current prices.
>
> Return to ministerial management in the mid-1960's may have arrested, or even reversed the trend in MB, since the 1959-66 decline of FD as a share of GVO may have been one result of the sormarkhoz experiment, which, among other things, was intended to reduce vertical integration of the production process. On the other hand, the sharp increase in materials prices in 1967 may have raised the ratio of intermediate products of GVO and hence reduced the ratio of FD to GVO. When the 1972 table is similarly reconstructed, we will have a third data point.[94]

---

[93] Vladimir G. Treml, Barry L. Kostinsky, Kurt W. Kruger, and Dimitri M. Gallik, Conversion of Soviet Input-Output Tables to Producers' Prices: The 1966 Reconstructed Table, FER No. 1, Washington, D.C.: U.S. Department of Commerce, Bureau of Economic Analysis, July 1973, pages 47-48, 68-69; and Vladimir G. Treml, Barry l. Kostinsky, and Dimitri M. Gallik, The 1959 Reconstructed Table, FER No. 6, Washington, D.C.: U.S. Department of Commerce, Bureau of Economic Analysis, February 1975, pages 45-46, 84-85.

[94] Op. Cit., Bill Lee's book on an unconventional approach, pages 237-238. Producers' prices are equal to the factory cost (sebestoimost) plus the permitted rate of profit; whereas, purchasers' prices are equal to producers' prices plus turnover tax, transportation and distribution costs. The 1959, 1966, and 1972 I/O tables used by Rush Greenslade for the computations in his Table 15 are in purchasers' prices--not producers' prices (underlining added for highlighting purposes).

On the basis of the foregoing citations, it is apparent that Bill Lee and Rush Greenslade are using different definitions of double-counting bias, as well as different sources of data, in order to test for the presence of double-counting bias. For purposes of clarifying these differences in definitions, MBMW GVO may be expressed symbolically as follows:

$$P_iX_i = P_ix_{ii} + \sum_{j \neq i}^{j=N} P_ix_{ij} + C_i \tag{15}$$

where P_iX_i represents the total MBMW GVO deliveries,

P_ix_{ii} represents the MBMW GVO intra-branch deliveries,

$\sum_{j \neq i}^{j=N} P_ix_{ij}$ represents the MBMW GVO inter-branch deliveries, and

C_i is the MBMW FD (i.e., final demand).[95]

Rush Greenslade's ratio in his Table 15 may therefore be expressed symbolically as follows:

$$(P_iX_i - P_ix_{ii})/P_iX_i = (\sum_{j \neq i}^{j=N} P_ix_{ij} + C_i)/P_iX_i \tag{16}$$

The decline of this ratio over time is evidence of increasing double-counting bias due to the reduction of vertical integration within the MBMW branch. By contrast, Bill Lee's definition of double counting bias may be expressed symbolically as follows:

$$(P_iX_i - P_ix_{ii} - \sum_{j \neq i}^{j=N} P_ix_{ij})/P_iX_i = C_i/P_iX_i \,. \tag{17}$$

---

[95] P_ix_{ii} also represents "sales within the MBMW sector" and $\sum_{j=i}^{j=n} P_ix_{ij}$ also represents "material sales to external non-MBMW sectors" Therefore, Equation (15) may be interpreted as the MBMW composite row in a Soviet I/O table. For future reference, the ratio of net value output to gross value output (NVO/GVO) is defined in Equation (16), where MBMW NVO = $P_iX_i - P_ix_{ii}$ = MBMW GVO - P_ix_{ii}.

Because Bill Lee's ratio did not decline between 1959 and 1966, he does have evidence for claiming that there is no double-counting bias for the MBMW branch. However, since Rush Greenslade presents evidence of reduced vertical integration within the MBMW branch between 1959 and 1966 in his Table 15, then by implication, Bill Lee has evidence of a relative decrease in vertical integration outside the MBMW branch for the same period. In fact, the only way that Rush Greenslade's ratio in Equation (16) can be decreasing while Bill Lee's ratio in Equation (17) is increasing between 1959 and 1966 is for the ratio of the MBMW GVO inter-branch deliveries to MBMW GVO to be declining rapidly.[96] Therefore, the difference between Bill Lee's and Rush Greenslade's alternative definitions of double-counting bias can be expressed in terms of the type of reduction in vertical integration of the MBMW production process over time.

On the one hand, Rush Greenslade's definition of double counting bias corresponds to a reduction in vertical integration within the MBMW branch over time and, on the other hand, Bill Lee's definition of double counting bias corresponds to a reduction in vertical integration within, as well as outside, the MBMW branch over time. These two types of vertical integration of the MBMW production process over time (i.e., within and outside the branch) may reinforce each other -- in which case, Rush Greenslade and Bill Lee will reach the same conclusion about the double counting bias. However, these two types of vertical integration may also offset each other -- in which case, Rush Greenslade and Bill Lee will reach opposite conclusions about the double counting bias.

---

[96] As may be observed, the degree of vertical integration within the MBMW branch can be measured by Rush Greenslade's ratio in Equation (16). When vertical integration is reduced, then this ratio declines and double counting bias is detected on the basis of Rush Greenslade's criteria. By contrast, Bill Lee requires that the degree of vertical integration outside the MBMW branch, as reflected in the $(\sum_{j \neq i}^{j=N} P_i x_{ij}/P_i X_i)$ ratio, be subtracted from Equation (16) in order to yield his criteria for double counting bias in expression (17). When vertical integration outside the MBMW branch decreases over time, then the ratio of MBMW GVO inter-branch deliveries to MBMW GVO will decrease. Consequently, the ratio in Equation (16) can be decreasing and the ratio in Equation (17) can be increasing between 1959 and 1966 only if $(\sum_{j \neq i}^{j=N} P_i x_{ij}/P_i X_i)$ is rapidly declining--which, in fact, is what happened.

The latter case, which is what occurred between 1959 and 1966, has resulted in the difference of opinion between Rush Greenslade and Bill Lee concerning the importance of the double-counting bias. Although Bill Lee's definition of the double-counting bias is more complete in an input-output (I/O) context because MBMW FD, not MBMW GVO, is the important magnitude within which to estimate NS durables as a residual, the initial Soviet data identified in the estimation procedure which is outlined at the beginning of Section 2.6.3 is MBMW GVO, not MBMW FD. In addition, Bill Lee has argued that NS durables cannot be derived from I/O tables becasue of inherent ambiguities in the I/O data. Consequently, Rush Greenslade's definition of double-counting bias may be less complete in an I/O context, but more relevant in terms of Soviet data for MBMW GVO. Therefore, the initial step of the residual estimation technique for NS durables requires that annual MBMW GVO of good quality be provided. In this context, Rush Greenslade's methodology for adjusting the originally reported values for an increasing trend in "reduced vertical integration within the MBMW branch" (which Greenslade defines as double-counting bias) is certainly plausible. As a result, the use of an adjusted value of MBMW GVO as the initial Soviet data in the foregoing estimation procedure will provide an alternative series of residual estimates for Soviet NSE to compare with Bill Lee's original estimates. If there is no significant difference between these two series, then Rush Greenslade's argument with respect to double-counting bias would have "negligible empirical content". It is in this context that Bill Lee appears to have justification for dismissing Greenslade's double-counting argument and continuing to use the originally reported value of MBMW GVO from Soviet sources. In any event, it is planned to include an empirical test of these opposing arguments in the future research program.[97]

---

[97] This empirical test for double-counting bias has been described by Bill Lee and will utilize his definition in Equation (17). The 1966 and 1972 I/O tables used by Rush Greenslade to obtain the ratios in Equation (16), which appear in his Table 15, should not be used because those I/O tables are in purchasers' prices--the source of which is identified in Footnote 92. By contrast, the original value of MBMW GVO reported by Soviet sources is in producers' prices (which explains Bill Lee's original use of reconstructed 1959 and 1966 I/O tables). Moreover, the reconstructed 1972 I/O table in producers' prices has not yet been processed. The hypothesis to be tested is that the vertical integration outside the MBMW branch has continued to decrease from 1966 to 1972 in sufficient magnitude to offset the observed decline in vertical integration within the MBMW branch from 1966 to 1972 as reflected in Rush Greenslade's Table 15. This hypothesis will be verified empirically if the ratio of MBMW FD to MBMW GVO does not decline between 1966 and 1972, which also corresponds to Bill Lee's deinition of a situation wherein no double-counting bias is present. A preliminary empirical test using the 1966 and 1972 I/O tables in purchasers' prices supports this hypothesis, but it must now be repeated using the reconstructed 1972 I/O table in producers' prices currently being processed.

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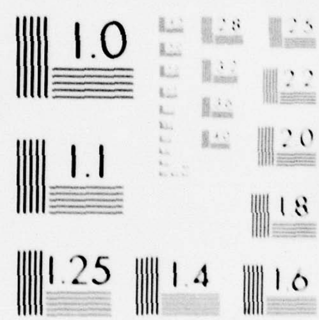

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2.6.4.2 Overpricing of New Products. The criticism of overpricing of new products as a source of bias has generally been focused upon the use of reported establishment profits in the MBMW sector to establish consistency between the official MBMW GVO series and derived MBMW production costs. This relationship may be summarized symbolically as follows:

$$\text{MBMW GVO} = TC + \pi \qquad (18)$$

where TC is total production costs, and

π is the reported MBMW profits.[98]

Bill Lee computes TC on the basis of labor input, as well as capital stock data, and amortization data as follows:

> From labor input data the methodology steps, for any given year, are as follows:
>
> 1. Labor force times average wage = the wage bill.
> 2. The wage bill divided by the percentage share of wages in aggregate production costs = TC (the aggregate production cost--(sebestoimost").
> 3. Production costs and profits = MBMW GVO in current prices.
>
> Similarly, MBMW GVO can be constructed from capital stock and amortization data:
>
> 1. Capital stock times amortization rates = amortization charges.
> 2. Amortization charges divided by the percentage share of such payments in aggregate production costs = TC (the aggregate production cost--"sebestoimost").
> 3. Production costs and profits = MBMW GVO in current prices.[99]

Although Bill Lee attains close agreement among his various calculations of TC plus π with the official MBMW GVO values in Equation (18), he does acknowledge the controversy involved in using the MBMW profits (π) reported in Soviet sources in the following terms:

---

98 Op. Cit., Bill Lee's book on an unconventional approach, Table B.5, page 223 which provides the MBMW profits for 1958 and 1974 from the official Soviet N.Kh. handbook.

99 Ibid., page 217. His calculations in Tables B.6, B.7, and B.9 on pages 225-228 are evaluated in Tables B.11 and B.12 on pages 232-234 (underlining added for highlighting purposes).

> Those who allege that MBMW GVO is systematically biased upwards by new product pricing usually cite Soviet sources in support of their allegations. Certainly the Soviet literature contains a number of examples of individual temporary prices which had excessive profit margins relative to the margins for products already in production. But Soviet sources also contain many statements that, on the average, profit margins on new products are lower than those on proven products. Indeed, the disincentive to introduce new products because of lower profit margins or even losses was the official rationale for introducing the special fund for "mastering new products" in 1961....Even more important, the TSU claims it has purged temporary prices from its calculation of MBMW GVO. In the absence of other evidence, this alone should satisfy the critics, unless, of course, they can show why the TSU is not to be taken at face value at this point...
>
> Some critics may object that use of reported establishment profit introduces the (alleged) new product-pricing bias into the calculations. The sensitivity of the previous calculations to the use of official profit data may be tested by substituting an imputed capital charge for profits as a component of value added.[100]

In order to properly interpret the foregoing observations, Equation (18) may be rewritten as follows:

$$\text{MBMW GVO} = P_i x_{ii} + \sum_{j \neq i}^{j=n} P_j x_{ji} + (L_i + K_i + A_i) = P_i X_i \qquad (19)$$

where $P_i x_{ii}$ is defined in Footnote 95,

$\sum_{j \neq i}^{j=n} P_j x_{ji}$ represents the inter-branch purchases or "material purchases from external non-MBMW sectors", and

$(L_i + K_i + A_i)$ is the MBMW value added, which consists of returns to labor, capital, and amortization charges.

It may be observed, that Equation (19) can be interpreted as the MBMW composite column in a Soviet I/O table, as opposed to Equation (15), which is the MBMW composite row. Therefore, the "new product pricing bias" residual can be calculated as the difference between Equations (18) and (19) as follows:

---

[100] Ibid., pages 248 and 262, plus Footnotes 9 and 11 on pages 269-270 (underlining added for highlighting purposes).

$$R_i^* = (TC+\pi) - \left[P_i x_{ii} + \sum_{\substack{j=n \\ j \neq i}} P_j x_{ji} + L_i + K_i + A_i\right] \geq 0 \qquad (20)$$

where $R_i^* > 0$ corresponds to the amount of book profit (π) that is "excessive" due to "new product pricing bias".

Any significant numerical estimates of R_i^* in Equation (20) can be used to adjust the original values of MBMW GVO used in the first step of the estimating procedure previously outlined at the beginning of Section 2.6.3 (i.e., MBMW GVO minus R_i^*), which will thereby reduce Bill Lee's original estimates of Soviet NSE in Table 2.11. This type of sensitivity analysis will be discussed later in this summary report using additional sources of information.[101]

Stanley Cohn has recently estimated R_i^* percentages overtime for the Soviet composite machine-building sector (i.e., the R_i^*/(MB GVO) ratios). These may be used to estimate the minimum amount of MBMW profit caused by new product pricing inflation--assuming that Stanley Cohn's estimating methodology is correct. The results, which are summarized in Table 2.13, provide a consistency check on the estimated percentage of new product pricing bias recently estimated by Stanley Cohn. The reported total MBMW profits in Column 2 are assumed by Bill Lee to include all "excessive profit margins" caused by any new product pricing bias that may exist. Consequently, if Stanley Cohn's estimated bias ratios in Column 4 are reasonably correct, then the minimum MBMW R_i^* estimates in Column 5 should be contained within the values of π in Column 2.[102] The differences between the MBMW profits (Column 2) and the new product pricing bias estimates (Column 5) are presented in Column 6. These values should be strictly positive and of substantial magnitude, provided Bill Lee's argument with respect to negligible overpricing of new products is correct. However, since the values in Column 6 are relatively small (and even negative in recent years), Table 2.13 suggests the following three possible explanations:

---

[101] As reflected in Table C.13 on page 263 of his book, Bill Lee has already performed a preliminary sensitivity analysis of his use of π in Equation (18). However, his MBMW capital stock in Column (1) does not contain working capital, only fixed capital. The estimates of both fixed and working capital should be used to determine the return to MBMW capital stock, K_i. Also, Bill Lee does not include amortization charges in his sensitivity analysis, for he essentially compares $L_i + K_i$ in Column (4) with $L_i + \pi$ in Column (6) of Table C.13, which represents a very incomplete analysis. Instead, he should start with MBMW GVO and end with R_i^* in Equation (20).

[102] The MB GVO values in Column 3 are uniformly less than the MBMW GVO values used by Bill Lee in Tables B.6, B.7, and B.9, as cited in Footnote 99. Consequently, by multiplying Column 4 of Table 2.13 by MB GVO, instead of MBMW GVO, then minimum estimates of R_i^* will result in Column 5.

Table 2.13

Initial Estimates of New Product Pricing Bias in MBMW GVO[103]
(billions of current rubles)

1	2	3	4	5	6
Year	MBMW Profits (π)	MB GVO (commodity basis in current rubles)	Stanley Cohn's Estimated R_i^*/(MB GVO) Ratios	Minimum MBMW R_i^* (new product pricing bias)	Consistency Check $\left[\begin{matrix}\text{MBMW}\\ \pi\end{matrix}\right] - \left[\begin{matrix}\text{Minimum}\\ \text{MBMW}\\ R_i^*\end{matrix}\right]$
1960	3.7	24.1	.141	3.4	0.3
1961	4.3	27.4	.150	4.1	0.2
1962	5.0	31.6	.142	4.5	0.5
1963	5.7	35.9	.139	5.0	0.7
1964	6.4	39.1	.136	5.3	1.1
1965	7.0	42.8	.150	6.4	0.6
1966	8.7	47.9	.129	6.2	2.5
1967	9.7	52.8	.125	6.6	3.1
1968	10.9	58.6	.126	7.4	3.5
1969	12.0	64.4	.134	8.6	3.4
1970	13.9	70.6	.137	9.7	4.2
1971	12.8	77.9	.148	11.5	1.3
1972	14.8	85.3	.142	12.1	2.7
1973	13.1	94.6	.144	13.6	-0.5
1974	14.7	104.3	.164	17.1	-2.4
1975	16.7	114.5	.174	19.9	-3.2

103 Sources of the figures presented in Table 2.13 are as follows:

- Column 2 is taken from Table B.5, page 223 of Bill Lee's book--with the exception of the entry for 1975 which was extracted from Robert J. Abbott's working paper for CIA on Estimating Soviet Spending for Military Hardware from Machinebuilding and Metalworking Statistics, September 1978, Table A-V, Row H, page 35. (All figures in Column 2 have been rounde to one decimal point).
- Column 3 is taken from Stanley H. Cohn's previously cited paper on the "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," Table 1, Column 5, page 4.
- Column 4 is taken from Table 9, page 25 of the same reference.
- Column 5 is Column 3 times Column 4 and provides a minimum estimate of new product pricing bias in MBMW GVO.
- Column 6 is Column 2 minus Column 5. This consistency check is based on the following statement by Bill Lee on page 237 of his book: "Traditionally, the mechanism for the alleged overpricing of new products has been temporary prices, which are alleged to have excessive profit margins. Such overpricing falls in the profit rather than in the production-cost component of wholesale prices".

- The MBMW profits in Column 2 may be almost entirely the result of the overpricing of new products;
- Stanley Cohn's particular methodology for the estimation of new product pricing inflation ratios in Column 4 of Table 2.13 may be in error; or
- The new product pricing bias may not be located in π, but rather in the TC component of $\overline{\text{MBMW GVO}}$ shown in Equation (18).

With respect to the first explanation, Bill Lee provides the following evidence which casts doubts upon its validity:

> Note that the increase in the ratio of GVO to production costs--that is, the share of profit in MBMW GVO--was virtually nil in the period 1955-73. Even in the mid-1960s the ratio has increased to only 117.6 percent, as compared to 110.5 percent in 1955. This, by itself, does not establish anything definite about new product pricing, but intuitively it does not suggest that overpricing of new products by assigning them temporary prices have very high profit rates relative to old products, since a change in the profit rate of this magnitude can be explained by normal cost reductions in the absence of commensurate price reductions.[104]

Consequently, either Stanley Cohn's R_i^* percentages are estimated incorrectly or the new product bias must be located in the estimated total production costs and not in the reported MBMW profits. Turning first to Stanley Cohn's estimating methodology, his version of Equation (20) is especially tailored for the Soviet composite machine-building sector as follows:

$$R_i^* = \text{MB NVO} - (L_r + K_r + M_e) \tag{21}$$

where MB NVO = the net value of MB output, or MB GVO less sales within the producing sector;

L_r = the returns to labor (i.e., wages plus fringe benefits);

K_r = the returns to capital (i.e., a nominal interest return to combined fixed and working capital stock plus amortization charges); and

M_e = material purchases from external sectors.[105]

---

104 Op. Cit., Bill Lee's book, page 239.

105 Op. Cit., Stanley H. Cohn, "Estimation of Miltiary Durables Procurement Expenditures from Machinery Production and Sales Data," page 20.

The crucial methodological assumptions made by Stanley Cohn in order to implement Equation (21) involve the estimation of "sales within the producing sector" required to estimate MB NVO and the estimation of "material purchases from external sectors" required to estimate M_e. Stanley Cohn outlines his methodology as follows:

> The recent revised estimates (June 1977) for GVO and final demand for MB and Industry, n.e.c. by the Foreign Demographic Analysis Division have also included revised magnitudes for both external (to MB sectors) materials purchases and internal (to MB sectors) sales for 1966. Since no corresponding revisions have been forthcoming for 1959 and 1972, it is necessary to improvise revisions for these benchmark years.
>
> The critical ratio for the revisions are those of external material purchases to GVO and internal sales to GVO. As for the first ratio in terms of producers' prices, for 1966 there is a slight fall from .337 in the earlier estimates to .330 in the June 1977 revisions. This minor change is also applied to the earlier estimated ratios for 1959 and 1972. These ratios are then multiplied by the revised GVO estimates derived... (see Table 2.10, Column 4).... to obtain ruble value for external materials purchases.
>
> For recalculation of internal sales the same procedure has been used. In the case of internal sales the 1966 revision shown no change in the internal sales/GVO ratio. Therefore, the revisions of the 1959 and 1972 ratios merely involve the multiplication of the earlier computed ratios by the revised GVO estimates. 106

This revised methodology follows the same procedures outlined in Table 2.10. When an alternative approach was suggested, then a new estimate of the 1972 (RATIO) was obtained and the issue of a declining or constant (RATIO) since 1966 could no longer be resolved by Stanley Cohn's new evidence which was based upon the revised 1966 I/O table. In order to test the sensitivity of Stanley Cohn's revisions for the benchmark years of 1959 and 1972, the ratios of the net value of machine-building output to the gross value of the machine-building output (i.e., MB NVO/MB GVO) in producers' prices are summarized in Table 2.14.

---

106 Ibid., Appendix D, page D1. The revision in the "external material purchases to GVO" ratio for 1966 to .330 cannot be confirmed by the data for 1966 in Table 8, page 24 of the same reference, because 13.3/47.9 equals .278--not .330 as cited (underlining added for highlighting purposes).

Table 2.14

A Summary of the Ratio MB NVO/MB GVO in Producers' Prices [107]

1	2	3	4	5	6
Year	MB GVO (billions of current rubles)	Internal Sales (intra-branch deliveries)	MB NVO (billions of current rubles)	Ratio of MB NVO/ MB GVO	Minimum MBMW R_i^* (new product pricing bias)
1959	20.8	3.4	17.4	(.836)	2.5
1966	47.9	13.2	34.7	.724	6.2
1972	85.3	22.0	63.3	(.742)	12.1

[107] The sources of the figures presented in Table 2.14 are as follows:

- Column 2 is from Table 2.10, Column 4;
- Column 3 is from Stanley Cohn's "Estimation of Military Durables Procurement Expenditures from Machinery Production and Sales Data," Table 8, Column 3, page 24;
- Column 4 is Column 2 minus Column 3;
- Column 5 is Column 4 divided by Column 2; and
- Column 6 is from Table 2.13, Column 5, and Table 8, Column 5, page 24 of the foregoing paper by Stanley Cohn.

As Stanley Cohn observed in the foregoing explanation of his methodology, the internal sales/GVO ratio for 1966 did not change. Only the 1959 and the 1972 ratios, which are reflected in the figures shown in parentheses in Column 5 (i.e., one minus the internal sales/GVO ratio) of Table 2.14, were revised. Since any decrease in the estimate of the 1959 ratio in Column 5 (i.e., .836) will cause an increase in the estimate of internal sales in Column 3 (i.e., 3.4), then the same increase may be subtracted from the estimate of the minimum MBMW R_i^* in Column 6. For example, if the 1959 I/O table were actually revised and if the MB NVO/MB GVO ratio for 1959 were found to be in the order of .776, then the estimate of the minimum MBMW R_i^* in Column 6 would be 1.25, or only half the current estimate. In the same manner, any decrease in the estimate of the 1972 ratio in Column 5 (i.e., .742) will cause an increase in the estimate of internal sales in Column 3 (i.e., 22.0) and this increase may be subtracted from Column 6. Therefore, if the 1972 I/O table were actually revised and if the MB NVO/MB GVO ratio for 1972 were found to be in the order of .671, then the estimate of the minimum MBMW R_i^* in Column 6 would be 6.1, or only half the current estimate. This declining trend in the ratio of MB NVO/MB GVO for 1959, 1966, and 1972 (i.e., .776, .724, .671) would also be

consistent with the evidence supplied by Rush Greenslade with respect to the ratio of MBMW NVO/MBMW GVO in his Table 15 on page 64. It is the absence of this declining trend in Stanley Cohn's estimates in Column 5 of Table 2.14 (i.e., .836, .724, .742) that raises questions with regard to his estimating methodology.[108] Would the removal of MW GVO and a change from purchasers' prices to producers' prices (i.e., removal of the turnover tax) actually reverse the declining trend which is evident in Table 15? If so, then Stanley Cohn has actually provided evidence for directly refuting Rush Greenslade's double-counting bias argument for MB GVO, which is the major component of MBMW GVO. Even Bill Lee does not dispute Rush Greenslade's evidence of a declining trend; he merely argues that Rush Greenslade is using an incomplete definition of double-counting bias. In any event, this criticism of Stanley Cohn's estimated R_i^* percentages cannot be conclusively resolved until the reconstructed 1972 I/O table in producers' prices is used directly in the computations.

Philip Hanson has recently presented a new argument in which he suggests that the new product pricing bias is actually located in the estimates of total production costs. Since the total production costs are estimated by dividing the estimated MBMW wage bill by the percentage share of wages in total costs (i.e., W/(share) = TC) and if this percentage share is biased downward, then the estimated values of TC will be biased upward. Since the data on the percentage share are obtained directly from Soviet statistical handbooks, these handbooks may be the source of the upward bias of new product pricing in the estimated MBMW GVO. The reason for a downward bias in the data on the percentage share is suggested by Philip Hanson in the following extract from his review of Bill Lee's book:

> One element, at least, in Lee's derivation of military procurement from MBMW output seems to be questionable. This is his treatment of the issue of bias in the Soviet constant price MBMW gross output index, arising from new product prices. On pages 9-10, he appears to accept the widely-held view that the Soviet official wholesale price index understates increases in the unit prices of machinery. In Chapter 9, however, he contends that this is probably not a quantitatively important source of bias; and in Appendix C he offers some ingenious empirical test of the Soviet data to support this view.

[108] The most serious criticism of Stanley Cohn's estimating methodology, and one which affects the credibility of the estimates of the percentage R_i^* for the period 1960-1965 as shown in Column 4 of Table 2.13, was introduced in Footnote 76.

His argument is that

(a): increased technological complexity of successive vintages of machines entails increasing unit costs not reflected in the official Soviet price index;

(b): these higher costs and prices do not, however, entail increased rates of profit, so that they do not, certeris paribus, lead to an overstatement of the growth of value added;

(c): any undetected inflation of prices is confined to civilian items, so that the subtraction of intermediate demand and an upward-biased constant price measure of final civilian demand from constant-price MBMW gross output should, if anything, lead to an understatement of output of military items.

Arguments (a) and (b) raise fundamental issues relating to the meaning and purposes of indices of prices and of 'real' output; they do not dispose of the contention that there is an upward bias in the pricing of new machines in terms of their productivity (and hence their (hypothetical) scarcity value) and that this bias is not eliminated by the official price index. As for argument, (c), it is simply not clear why any such "overpricing" should be confined to civilian machinery.

In general, the derivation of military procurement from Soviet engineering output data is not straightforward and reliable. The Soviet Central Statistical Administration is not, after all, working for customers in Washington. Certainly, Lee explains and defends his method ably, and may well be on the right lines; at all events, his calculation of procurement in 1970 comes out reasonably close to the CIA's revised view. But judgement on whether he has really developed a sound method will have to be deferred until the data and method are re-worked by others and the results compared over a period of time with estimates arrived at by different methods. [109]

If the new product pricing bias is identified with the machinery cost portion of the total production costs based upon Philip Hanson's suggestion, then the Soviet reported percentage share of wages in total production costs will actually be "too low" because their own total costs are "too high". In other words, this application of the Soviet reported percentage share data (which have a downward

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[109] Op. Cit., Philip Hanson, "Reviews: Estimating Soviet Defense Expenditure" in Soviet Studies, pages 406-407 (underlining added for highlighting purposes). It is conventional wisdom that approximately one-third of MBMW output is pegged at "temporary prices" used for new products during the period of "mastering production" which are higher than the "permanent prices" at which they will eventually be established. As observed by Morris Bornstein ("Soviet Price Statistics", Soviet Economic Statistics, V. Treml and J Hardt (editors), 1972, page 361,) "the index for machine-building and metalworking industries misstates the direction of price changes in this branch".

bias) for estimating the TC component of MBMW GVO in Equation (18) will introduce an upward bias in these estimates of TC which may be attributed to the general pattern of overpricing new machinery in the MBMW gross value of output.

The magnitude of this new product pricing bias, which is located in the TC component of MBMW GVO instead of in the π component, can be estimated after modifying the three-step methodology utilized by Bill Lee as described by Robert J. Abbott of CIA's Military-Economic Analysis Center:

> For the years after 1966, however, this method must be modified to yield accurate estimates. Since 1967, Soviet average wages and wage funds have included bonus payments from the material incentive fund, the source of which is profit. But bonuses paid from profit are not included in production costs. To estimate GVO from labor costs and profit, therefore, one should:
>
> 1. Multiply the branch's reported wage fund by one plus the estimated rate of social insurance contributions (the enterprise makes social insurance contributions on most bonuses as well as on regular wages),
> 2. Deduct payments from the material incentive fund derived from profits,
> 3. Divide the result by the reported (from the Soviet Narodnoye Khozyaystvo SSSR statistical handbook) "share" of wages and social insurance costs in total production outlays,
> 4. Add reported profits to the quotient.[110]

The adjustment in Step 2 of the modified methodology was originally suggested by Professor Vlad Treml of Duke University, while the new product pricing bias suggested by Philip Hanson is introduced in Step 3.

In order to estimate directly the new R_i^* percentages overtime for the Soviet composite machine-building and metalworking sector (i.e. R_i^*/MBMW GVO ratios), an alternative estimating methodology must be developed to replace Equation (18). This alternative estimating methodology for MBMW GVO is based upon the following two vital pieces of information:

[110] Robert J. Abbott, Estimating Soviet Spending for Military Hardware from Machinebuilding and Metalworking Statistics, CIA working papers, September 1978, page 29. The term "wage fund" is used by Soviet sources in both a narrow and a broad sense--the former excluding bonuses paid from profit and the latter including such bonuses. In the four-step methodology outlined by Robert J. Abbott, the term "wage fund" is used in its broad sense.

- The Soviet TSU MBMW GVO index for 1966 to 1975, and
- A Gosplan planned value of MBMW GVO for 1970 in billions of July 1, 1967 rubles.[111]

The MBMW GVO series generated by this alternative methodology must be converted to current rubles and subtracted from the estimates of MBMW GVO generated by the three-step methodology used by Bill Lee, as well as the four-step methodology described by Robert Abbott. The resulting differences provide alternative time series estimates of MBMW R_i^* (new product pricing bias) which may then be compared with Column 5 of Table 2.13. These alternative estimates of the new product pricing bias in Soviet MBMW GVO, both without and with the "Treml adjustment" in Step 2, are summarized in Table 2.15. The estimates of MBMW GVO in current rubles (i.e., Columns 2 and 3 of Table 2.15) provide a direct implementation of Equation (18) without and with the "Treml adjustment," respectively. The estimates of MBMW GVO in constant 1967 rubles in Column 4 of Table 2.15 are converted to the current ruble estimates in Column 5, which constitutes an alternative MBMW GVO series. As a consequence, the "unadjusted" estimates of the new product pricing bias, $\hat{R}_i^*$, in Column 6 may be compared with Column 5 of Table 2.13. In addition, the estimates of the "unadjusted" new product pricing bias MBMW $\hat{R}_i^*$ percentage ratios in Column 8 of Table 2.15 may be compared with Stanley Cohn's estimates in Column 4 of Table 2.13. As may be observed, there is relatively close agreement between Stanley Cohn estimates (MBMW R_i^*) for the period 1969-1975 in Table 2.13 and those of Bill Lee (MBMW $\hat{R}_i^*$)in Table 2.15. This suggests that Stanley Cohn's estimated R_i^* percentages for the period 1960-1968 in Table 2.13 are vulnerable to the methodological criticism introduced in Footnote 76, but the same criticism apparently does <u>not</u> apply for the period 1969-1975. However, the "Treml adjustment" previously cited in connection with the modified, four-step methodology for estimating MBMW GVO does reduce the estimated new product pricing bias, $\tilde{R}_i^*$, in Column 7 of Table 2.15. Consequently, Robert Abbott's estimates of MBMW $\tilde{R}_i^*$ in Table 2.15 may be favorably compared with the MBMW Profits (i.e., π

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[111] The Soviet TSU MBMW GVO index is obtained from the Soviet statistical handbook, <u>Narodnoye Khozyaystvo SSSR</u>, and the Gosplan planned value of MBMW GVO for 1970 is obtained from USSR Gosplan, <u>Gosudaratvennyy pyatiletniy plan razvitiya narodnogo khozyayetva SSSR na 1971-1975 gody</u> (Moscow, 1972), pages 346-347.

Table 2.15

Alternative Estimates of the New Product Pricing Bias in MBMW GVO [112]
(billions of current rubles)

1	2	3	4	5	6	7	8	9
Year	Lee MBMW GVO Series	Abbott MBMW GVO Series	Gosplan MBMW GVO (constant 1967 rubles)	Gosplan MBMW GVO (current rubles)	Lee MBMW $\hat{R}_i^*$ Estimated BIAS	Abbott MBMW $\hat{R}_i^*$ Estimated BIAS	Lee $\hat{R}_i^*$ Percentage RATIOS	Abbott $\hat{R}_i^*$ Percentage RATIOS
1966	58.146	58.745	54.3	54.3	3.846	4.445	.066	.076
1967	66.845	66.182	61.1	61.1	5.745	5.082	.086	.077
1968	75.940	74.459	68.7	68.7	7.240	5.759	.095	.077
1969	83.568	81.150	76.3	74.8	8.768	6.350	.117	.078
1970	94.625	89.809	84.8	83.1	11.525	6.709	.122	.079
1971	100.512	95.369	94.1	84.7	15.812	10.669	.157	.112
1972	109.598	104.241	105.2	94.7	14.898	9.541	.136	.092
1973	115.005	108.832	117.9	100.2	14.805	8.632	.129	.079
1974	126.976	119.730	131.4	107.7	19.276	12.030	.152	.100
1975	(139.541)	130.982	146.7	120.3	19.241	10.682	.138	.081

[112] The sources of the figures presented in Table 2.15 are as follows:

- Column 2 is taken from Bill Lee's book on an unconventional approach, Table B.6, page 225. However, the 1975 entry in parentheses was calculated by means of Bill Lee's three-step methodology.
- Column 3 is taken from Table A-V, Row I, page 35 of Robert Abbott's working paper previously cited in Footnote 110.
- Column 4 is taken from Bill Lee's book, Table A.6, Column 4, page 75, but is also available from Robert Abbott's paper in Table 1, Row D, page 3.
- Column 5 is obtained by multiplying Column 4 by the Official Soviet MBMW Wholesale Price Index (July 1, 1967) from Bill Lee's book (Table B.10, page 230) for the period 1966-1975.
- Column 6 equals Column 2 minus Column 5.
- Column 7 equals Column 3 minus Column 5.
- Column 8 equals Column 6 divided by Column 2.
- Column 9 equals Column 7 divided by Column 3.

values) in Table 2.13 for the period 1966-1975.[113] Robert Abbott's "adjusted" new product pricing bias percentage ratios, $\tilde{R}_i^*$, for the period 1966-1975 in Column 9 of Table 2.15 may then be used to adjust the values of MBMW GVO in current rubles <u>after</u> the "Treml adjustment" is performed on Column 3 of Table 2.15. It is therefore clear that overpricing of new products is an important source of bias in the application of Equation (18) for estimating MBMW GVO in current rubles. However, the source of this bias need <u>not</u> be concentrated in the use of reported profits, π, as may be generally believed. Instead, the source of this bias can be concentrated in the estimates of total production costs, TC, as illustrated in Table 2.15.

2.6.4.3 <u>Comparability of Data</u>. The criticism with regard to the compatibility of MBMW GVO data from the I/O tables with USSR TSU and Gosplan MBMW GVO data has been previously cited in this summary report (as referenced in Footnote 68). Although this incompatibility appears to have been resolved by virtue of the new information provided by Stanley Cohn (as referenced in Footnote 70), there is still a conceptual dispute between Bill Lee and Stanley Cohn with respect to the establishment basis versus the commodity basis for estimating national security durables (as referenced in Footnotes 71 and 72). Even though the ratio of commodity to establishment production for the MBMW sector in the 1972 I/O table in producers' prices is significantly greater than the value (i.e., .86) assumed by Bill Lee (as referenced in Footnote 73), some questions still remain. For example, as explained by Robert Abbott of the CIA,

> Part of the difference between the "official" statistics and the estimates in the reconstructed input-output tables also may be a matter of different measures of output. The "official" figures, like MBMW GVO data reported before 1972, are probably "establishment" statistics, which report the total output of all MBMW establishments, including non-MBMW output. The reconstructed input-output table data are "commodity" statistics which report total MBMW output, including that of non-MBMW establishments. But the

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[113] The "consistency check" corresponding to the Robert Abbott's estimates of the new product pricing bias for the period 1966-1975 are 4.25, 4.62, 5.14, 5.65, 7.19, 2.13, 5.26, 4.47, 2.67, and 6.01, which are all positive as required. Consequently, Stanley Cohn's estimating methodology in Equation (21) should be modified to include the "Treml adjustment" which would cause the values of MBMW R_i^* values in Column 5 of Table 2.13 <u>subsequent to 1965</u> to be in closer agreement with the values of MBMW $\tilde{R}_i^*$ in Column 7 of Table 2.15.

> information which published Soviet sources provide on the size of difference between "commodity" and "establishment" MBMW GVO does not satisfactorily explain the differences between the reconstructed input-output table estimates and the "official" Soviet figures. In 1959, the reported ratio of "commodity" to "establishment" MBMW GVO was 0.92. Published Soviet data suggest that it ranged from 0.92 to 0.94 during 1966-75. (In a "private communication" to W.T. Lee, a former Soviet economist reported that the ratio was 0.88 in 1966, but this is contradicted by the data just mentioned.) But for both 1966 and 1972 the "commodity" to "establishment" ratio implicit in a comparison of the reconstructed input-output table estimates of MBMW GVO and the "official" MBMW GVO statistics is much higher--1.125 for 1966 and 1.031 or 1.146 in 1972 depending on whether or not the Soviet producers' price index is used to convert the estimate from the reconstructed input-output table to 1967 prices.
>
> Neither the Soviet producers' price index nor the published information on the difference between "commodity" and "establishment" output, therefore, sufficiently explains the differences between Western estimates of MBMW GVO in the reconstructed input-output tables for 1966 and 1972 and the "official" Soviet statistics for these years. The Western estimates may not be final. The estimate for 1966 is a recent revision of earlier published estimates and the estimate for 1972 is, as yet, unpublished and still subject to change. [114]

In this context, the MBMW GVO series shown in Column 4 of Table 2.15 was originally identified on a commodity basis by Bill Lee, but was later identified on an establishment basis by Robert Abbott, who offered the following explanation:

> In his recent work, W.T. Lee makes an interesting "circumstantial" case for the hypothesis that the MBMW GVO data reported by Gosplan and the post-1972 handbook MBMW data are "commodity" statistics. Lee's argument is based on the virtual equivalence of the the MBMW GVO for 1966 calculated from the reports of Gosplan and the economic handbooks (54.3 billion rubles), and the estimate of MBMW GVO in an early reconstruction of the 1966 Soviet input-output table (54.9 billion rubles). Now that the estimate of MBMW GVO in the reconstructed input-output table for 1966 has been revised to 61.1 billion rubles Lee's case is weakened considerably. In the absence of evidence to the contrary and in the light of past Soviet practice, the MBMW GVO statistics reported since 1972 can be assumed to be "establishment" data. [115]

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114 Op. Cit., Robert J. Abbott, Estimating Soviet Spending for Military Hardware from Machinebuilding and Metalworking Statistics, pages 4-6 (underlining added for highlighting purposes).

115 Ibid.

In view of the revisions of the I/O tables, it would therefore appear that Bill Lee's old commodity basis estimates may be reinterpreted as new establishment basis estimates. Consequently, there still appears to be some uncertainty with regard to the compatibility of MBMW GVO data from the I/O tables with the official Soviet TSU and Gosplan MBMW GVO data. Moreover, since additional revisions of the 1966 and the 1972 I/O tables may cause the estimated commodity-to-establishment-basis ratio to change again, then for the time being, Bill Lee's commodity basis estimates of Soviet NSE do provide a consistency check on his establishment basis estimates. A comparison of D_{4t}, D^*_{4t}, D_{5t}, and D^*_{5t} in Tables 2.11 and 2.12 reveals that Bill Lee's commodity basis estimates for NSE (D_{5t}) offer what might be called a "middle ground" between Bill Lee's establishment basis estimates (D^*_{5t}) and Stanley Cohn's commodity basis estimates (D^*_{4t}). This "middle ground" characteristic is reflected primarily in a comparison of the estimates of NS durables in the foregoing tables (i.e., γ_{4t}, γ^*_{4t}, γ_{5t}, and γ^*_{5t}). Bill Lee's commodity basis estimates for procurement (γ_{5t}) have been higher than Stanley Cohn's commodity basis estimates (γ^*_{4t}) since 1970, but lower than his own establishment basis estimates (γ^*_{5t}). The future resolution of methodological differences between Bill Lee and Stanley Cohn concerning the Production Residual Estimation Technique, which has been extensively reviewed in this summary report, should result in the convergence of these procurement estimates (γ^*_{4t} and γ_{5t}).[116] Inasmuch as both of these estimates are on a commodity basis, then any difference which still remains between γ_{5t} and γ^*_{5t} would reflect:

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[116] As a matter of information, the Residual Estimation Technique was also used much earlier by Michael Boretsky in "The Technological Base of Soviet Military Power," Economic Performance and the Military Burden in the Soviet Union, Joint Economic Committee report, 1970, pages 189-231. However, a number of controversial assumptions that were used in this paper became the focus of a debate between Michael Boretsky and Alec Nove in "The Growth of Soviet Arms Technology: A Debate," in Survival, Volume XIV, Number 4, (July/August, 1972), pages 169-177. The "high" dollar/ruble ratio advocated by Michael Boretsky was questioned by Alec Nove. This debate was similar to that encountered by CIA personnel a number of years later in connection with the "too low ruble/dollar ratio" within their own direct costing estimation technique--which will be discussed later.

Another source of error associated with the Residual Estimation Technique has recently been identified by Paul Cockle in "Analysing Soviet Defense Spending: the Debate in Perspective," Survival, Volume XX, Number 5, September/October, 1978, page 213. According to him, "Soviet export figures contain their own residuals which some analysts believe cover wholly or partially the export of weapons. Machine-building export data is therefore likely to exclude the value of arms transfers and so the final output residual is probably inflated by weaponry destined to go abroad. In the past, weapon exports as a proportion of production could have been dismissed as insignificant, but not now".

- The magnitude of the methodology error resulting from the use of an establishment basis definition of MB GVO, as criticized by Stanley Cohn, or
- An information error resulting from the use of the 0.88 commodity-to-establishment-basis ratio.

Furthermore, any remaining difference between Y_{4t} and Y^*_{4t} would reflect the magnitude of the information error associated with Stanley Cohn's hypothesis that State Reserves are included in the working capital accounts published in Narodnoe Khoziaistvo, as criticized by Bill Lee (reference Footnote 30). In addition, the methodologies developed in this summary report for breaking the "defense budget straight jacket" in estimating the Soviet Operating Budget (as reflected in Table 2.7) and for estimating Soviet military R&D expenditures (as reflected in Equation 13) provide the basis for the future convergence of the estimates of Soviet NSE (D^*_{4t} and D_{5t})--which would reflect the elimination of those methodology and information errors that have currently been identified and which will be the focus of future empirical research pertaining to the numerical estimates presented in this report.[117]

2.7 THE NATIONAL EXPENDITURE METHOD

The sixth baseline methodology for estimating Soviet NSE is the National Expenditure Method developed by the French. In this methodology, Soviet military R&D expenditures are estimated on the basis of the previously discussed rule-of-thumb that they constitute two-thirds of the Science line item in the budget. However, French estimates of the procurement portion of Soviet defense spending are based upon an economic methodology utilizing national accounting data which is generally described as follows:

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117 As an example of possible future empirical research involving the statistical relationships between two of the baseline estimating methodologies described in this report, Paul Cockle estimated in Footnote 28, page 214 of the article cited in Footnote 116 that:

$$Y = -2.42 + 1.0002X + 0.754T$$

where $Y = Y^*_{5t} + \beta^*_{5t}(\text{Science})_t$ is Bill Lee's hardware and military R&D estimate

$X = Y_{3t} + 0.75(\text{Science})_t$ is the FNE and BE residual plus 75% of the All Union Science Budget; and

T is time where 1955 = 1 and 1972 = 18.

The R^2 is 0.946 and the t values for the X and T variables are 3.814 and 9.221, respectively.

The fundamental objective of this proposed method is to identify the amount of investment spending contained in the national expenditure. The Net National Expenditure details the uses made--consumption, investment--of the Net National Product (in Russian: Natsional'nyy dokhod). The latter is erroneously equated with the National Income but it differs from the National Income on two points:

(a) It reflects only equipment production.

(b) It expresses the value of that production at market price and not at factor cost.

It is, therefore, really a Net Equipment Product (PMN) at market price. On the other hanu, the PMN may be compared to the PIB (Gross Domestic Product) of France's national accounting. Investment spending can be broken down into armament expenditures and scientific research expenditures.

It is officially agreed[118] that armament expenditures--considered in the West as consumption by government departments--are listed in national Soviet accounting under headings associated with net capital formation, called accumulation. That part of capital formation used for military purposes can be isolated by a series of calculations.[119]

Furthermore, the French methodology for estimating the Soviet Operating Budget is briefly outlined as follows:

Ordinary expenditures may be reconstructed around two entries: personnel costs (X_t) and current operating costs (Y_t). Inasmuch as military personnel strength figures are relatively perceptible and military pay scales are known with satisfactory accuracy, there is a certain reliability to the personnel costs estimate secured through the building-block approach and, therefore, this estimate may be retained: 8-9 billion rubles for the period 1971-1975.

From these figures, it is possible to estimate operating costs granting that in Soviet administrations such costs account for, on an average, 42 percent of the personnel costs.[120]

Generalization of the French methodology in terms of generic Equation (1) is based upon the following assumptions, all of which may then be substituted in (1):

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[118] In this context, see the "Basic Principles for Drawing Up a Strategic Balance Sheet of the National Economy" published by the United Nations Economic and Social Council, New York, 1972.

[119] Defense Nationale, "How Many Rubles for Defense?", Paris, France, November 1976, page 34.

[120] Ibid., page 35 (underlining added for highlighting purposes).

$\alpha_{6t} < 1$ for $t = 1971, \ldots, 1975$ (i.e., the Soviet Operating Budget),

$\beta_{6t} = 2/3$ for $t = 1971, \ldots, 1975$ (i.e., military R&D), (22)

γ_{6t} = the accumulation residual from the Soviet national income accounts associated with net capital formation (i.e., defense procurement), and

$\delta_{6t} = 0$ [121]

If, as described by the French, the Soviet Operating Budget can be disaggregated into the following two major categories

- X_t, which represents personnel expenditures (i.e., SIPRI categories 1 and 2), and
- Y_t, which represents non-personnel operating expenditures (i.e., SIPRI category 3),

Then, based upon the general formulation of Equation (7), the Soviet Operating Budget from 1971 to 1975 may be expressed in the following terms:

$$(X_t + \tilde{Y}_t) = \tilde{a} + (\tilde{b} + 1)\, X_t \text{ for } t = 1971, \ldots, 1975 \qquad (23)$$

with $\tilde{a} = 0$ and $\tilde{b} = .42$ determined by an unknown procedure.

In this context, a significant difference in the various estimating methodologies may be reduced to a simple statistical test performed upon the estimated parameters a and b. For example, Bill Lee's estimates in Equation (11) (i.e., $\hat{a} = 0$ and $\hat{b} = 1.48$) and the French estimates in Equation (23) (i.e., $\tilde{a} = 0$ and $\tilde{b} = .42$) may be compared with the least squares estimates in Equation (8) (i.e., $\hat{a}$ and $\hat{b}$) using Bill Lee's observations on X_t and Y_t over the sample period 1960-1970. However, since each each estimating methodology has different values for both X_t and Y_t over the prediction period 1971-1975, then each estimate of the parameter α_t must reflect the sampling variability of the estimated parameters a and b, the values of X_t, and ε_t. This may be illustrated by dividing Equation (9) by $(\text{Defense})_t$ as follows:

$$\alpha_t^* = (X_t^* + Y_t^*)/(\text{Defense})_t = [a^* + (b^* + 1)X_t^* + \varepsilon_t]/(\text{Defense})_t \qquad (24)$$

Furthermore, inasmuch as the formula for $\text{Var}(\hat{\alpha}_t)$ in Equation (10) reflects the sampling variability of the least squares estimates of parameters a and b and

[121] Ibid., pages 47-55

the ε_t stochastic term associated with the linear specification in Equation (7), it is appropriate for a given data set of X_t and Y_t values. However, in order to examine null and alternative hypotheses concerning the parameter α_t using the various data sets of available values for X_t^* and Y_t^*, a more general formula for the sampling variance of α_t^* in Equation (24) is required and may be expressed as follows:[122]

$$\mathrm{Var}\,(\alpha_t^*) = \mathrm{Var}(\hat{\alpha}_t) + \left[(\sigma_e^2/n) + b^2\sigma_{x^*}^2\right]\left[1/(\mathrm{Defense})_t^2\right] \qquad (25)$$

$$= \left[\sigma_e^2/(\mathrm{Defense})_t^2\right]\left[a + \frac{2}{n} + \frac{(X_t - \bar{X}_t)^2}{\sum_{i=1960}^{i=1970} (X_i - \bar{X}_*)^2} + b^2\sigma_{x^*}^2/\sigma_e^2\right]$$

where σ_e^2 is the residual variance associated with estimating ε_t,

$\sigma_{x^*}^2$ is the population variance associated with estimating X_t, and

$\bar{X}_*$ is the sample mean of the $n = 11$ estimates (i.e., X_t^* for $t = 1960, \ldots, 1970$) associated with a given estimating methodology.[123]

The Tchebychev inequality can be used to construct the following 95 percent confidence intervals for the α_t parameters in the $t = 1971, \ldots, 1975$ forecast period:

$$P\left[\alpha_t^* - k(\mathrm{Var}(\alpha_t^*))^{1/2} \leq \alpha_t \leq \alpha_t^* + k(\mathrm{Var}(\alpha_t^*))^{1/2}\right] \geq .95 \qquad (26)$$

where $k = 4.47$, if no additional assumptions are made, and

$k = 2.96$, if the probability distribution is assumed to be unimodal and symmetric.

A summary of the available sample and projected values for α_t^* associated with the French, Bill Lee's and the CIA estimating methodologies is presented in Table 2.16.

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[122] Martin S. Feldstein, "The Error of Forecast in Econometric Models when the Forecast-Period Exogenous Variables are Stochastic," Econometrica, Volume 32, Number 1, January 1971, pages 55-60.

[123] Ibid., Formula (4) with one exogenous variable and an intercept, page 56.

[124] Ibid., Formula (5) and Footnote 4 on page 57. As may be observed, if the probability distribution is further assumed to be normal, then $k = 1.96$ can be used. However, these alternative values of k correspond to a 95, 88, or 74 percent level of confidence, if the additional assumptions which are made are not appropriate.

The French estimates of the Soviet Operating Budget in Column 5 of Table 2.16 are identified by Equation (23), and the estimates of the Column 6 correspond to the French null hypothesis in Equation (22) that $\alpha_t<1$ (i.e., $\alpha_{6t}<1$) of the forecast period for 1971 to 1975. Since there are no French estimates of the Soviet Operating Budget for the sample time period 1960-1970, a test of the French null hypothesis requires that Equation (26) be empirically implemented. In this context, it should be remembered that Stanley Cohn's alternative hypothesis is that $\alpha_t=1$ (i.e., $\alpha_{4t}=1$) for the same forecast period. Therefore, Stanley Cohn's data set for X and Y in Columns 3 and 4 of Table 2.7 for the period 1960-1970 can be used to estimate the $\bar{X}_*$, σ_ε^2, a, b, and σ_{x*}^2 parameters required to implement Equations (25) and (26). By using $\alpha_t^* = 1$ and letting the French estimates of $\tilde{\alpha}_{6t}$ in Column 6 of Table 2.16 be the numerical implementation of α_t in Equation (26), the French null hypothesis may be statistically tested. If the French estimates of $\tilde{\alpha}_{6t}$ are contained within these confidence intervals for the forecast period t = 1971,..., 1975 using Stanley Cohn's sample data to estimate the population parameters, then the null hypothesis is accepted. If, however, the French estimates of $\tilde{\alpha}_{6t}$ are not contained within these confidence intervals, the null hypothesis is rejected, and it may therefore be concluded that the difference between the French and Stanley Cohn's estimating methodologies for the Soviet Operating Budget is statistically significant. Accepting or rejecting the null hypothesis in this context may be interpreted as a statistical test for evaluating the different estimating methodologies which produced the French and Stanley Cohn's alternative estimates of the Soviet Operating Budget.

As may also be recalled, Bill Lee's alternative hypothesis is that $\alpha_t>1$ (i.e., $\alpha_{5t}>1$ for the same forecast period, so that the values of $\hat{\alpha}_{5t}$ in Column 7 of Table 2.16 may be substituted for α_t^* in Equation (26) and Bill Lee's data set for X and Y in Columns 6 and 7 of Table 2.7 will be used to estimate the $\bar{X}_*$, σ_ε^2, a, b, and σ_{x*}^2 parameters required to implement Equations (25) and (26).[126] Again, by allowing the French estimates of $\tilde{\alpha}_{6t}$ to be the numerical implementation of α_t in Equation (26), the French null hypothesis may be statistically tested for the

126 If Bill Lee's hypothesis reflected in Footnote 48 is to be used for the Y observations, then Column 7 minus Column 2 plus Column 9 in Table 2.7 will define the new set of Y observations.

Table 2.16

A Summary of Alternative Estimates of Parameter α_{it} for the Period 1971-1975 [125]

1	2	3	4	5	6	7	8
Year	Official Soviet Defense Budget $(\text{DEFENSE})_t$	French Personnel Costs (X)	French Non-Personnel Costs (Y)	French Estimates of the Operating Budget (X+Y)	Ratio of French Operating Budget Estimates ($\bar{\alpha}_{6t}$)	Ratio of Bill Lee's Operating Budget Estimates ($\hat{\alpha}_{5t}$)	Ratio of CIA's Operating Budget Estimates ($\bar{\bar{\alpha}}_{7t}$)
1960	9.3					1.000	.968
1961	11.6					.871	.827
1962	12.6					.849	.817
1963	13.9					.820	.784
1964	13.3					.910	.880
1965	12.8					1.000	.969
1966	13.4					1.000	.985
1967	14.5					1.000	.972
1968	16.7					1.000	.898
1969	17.7					1.000	.904
1970	17.9					1.000	.950
1971	17.9	8.2	3.5	11.7	.653	1.078	1.011
1972	17.9	8.4	3.5	11.9	.665	1.134	1.078
1973	17.9	8.6	3.6	12.2	.681	1.235	1.151
1974	17.6	8.8	3.7	12.5	.710	1.312	1.244
1975	17.4	9.0	3.8	12.8	.736	1.385	1.339

[125] Sources of the information presented in Table 2.16 are as follows:

- Column 2 is taken from Column 2 of Table 2.7--the data are in billions of current rubles;
- Columns 3 and 4 are taken from Table 3, page 35 of the Defense Nationale article, "How Many Rubles for Defense?", November 1976;
- Column 5 is Column 3 plus Column 4 in billions of current rubles;
- Column 6 is Column 5 divided by Column 2;
- Column 7 is Column 9 of Table 2.7 divided by Column 2; and
- Column 8 is Column 10 of Table 2.7 divided by Column 2.

forecast period. If the French $\tilde{\alpha}_{6t}$ estimates are contained within these confidence intervals using Bill Lee's sample data to estimate the population parameters, then the null hypothesis is accepted. If, however, the French estimates of the ratio $\tilde{\alpha}_{6t}$ are not contained within these confidence intervals, the null hypothesis is rejected and it is therefore concluded that the difference between the French and Bill Lee's estimating methodologies for the Soviet Operating Budget is statistically significant.

Clearly, the same statistical testing methodology may be used with the CIA alternative hypothesis, which also involves $\alpha_{7t}>1$ for the same forecast period. The particular values of $\tilde{\alpha}_{7t}$ for the period 1971-1975 to be substituted for α_t^* in Equation (26) are presented in Column 8 of Table 2.16. Robert Leggett and Sheldon Rabin have formulated the following non-statistical hypothesis concerning the Soviet defense budget--which is actually Stanley Cohn's estimate of the Soviet Operating Budget from 1960 to 1975:

> The hypothesis that the Soviet defense budget encompasses only operating expenditures can be tested by comparing the budget with Western estimates of the USSR's annual military operating costs....A comparison of the Soviet defense budget with various Western estimates of Soviet operating expenditures is shown (i.e., Table 2.7). The CIA series for 1960-75 was the most useful in this exercise because it was derived by means of a building block approach and hence is independent of the Soviet defense budget.[127] Note that the CIA estimates, which are expressed in 1970 rubles, were converted to current rubles in order to make a direct comparison with the Soviet data. A two percent rate of inflation was assumed in this exercise.
>
> William Lee's estimates through 1970 are dependent upon published Soviet data. Lee calculated nonpersonnel operating expenditures by subtracting his estimate of military personnel costs from the published defense budget. By definition, then, Lee's estimates for the period before 1971 coincide (almost) exactly with the Soviet defense budget (except for 1961-64) and were therefore not used in the comparison exercise. For the years 1971-1975, however, Lee's estimates were useful in that they were calculated independently of the budget; nonpersonnel costs were estimated as a percentage of personnel expenditures.

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[127] The building block approach involves identifying Soviet military programs, estimating the magnitude of the quantities involved in each program, and then applying estimated individual prices to each quantity.

The semi-official French estimates were also derived by independently calculating personnel cost, with nonpersonnel expenditures assumed as a percentage (42%) of personnel outlays. Unfortunately for our purposes, the French series covers only the period 1971-75.

The only western data available, therefore, to compare with the Soviet data over the 1960-1970 period are the CIA estimates. A comparison of the two series shows that the CIA data coincide closely with the official Soviet defense budget, thereby lending support to the operating budget hypothesis. The published budget figures not only fall within the range estimated by CIA, but both series are increasing over the entire period.

While our hypothesis appears to be reasonable for the years 1960-70, the same cannot be said for the rest of our test period.

The CIA and Lee estimates of operating costs for 1971-75 are, at best, only roughly comparable to the official defense budget. Moreover, the gap between these Western estimates and the Soviet data becomes greater over time. Given the data inaccuracies and definitional uncertainties inherent in the Western estimates, however, the differences by themselves are probably not substantial enough to reject the hypothesis.

A markedly different picture is seen in the French estimates, which suggest that Soviet military operating costs were substantially less than the announced defense budget during 1971-75.

The common ground for all the Western estimates for 1971-75, however, is that their (increasing) trend--about which we are most confident--differs totally from that presented by the Soviet data. All the Western estimates show Soviet operating costs to be increasing throughout this period, while the explicit Soviet defense budget remains virtually constant or decreases. Even the lowest Western series, the French estimates, indicates a positive growth rate for the 1970s albeit a much slower rate than the CIA or Lee series. Hence, in contrast to the 1960s, there does not appear to be much support in the 1970s for the hypothesis that the announced defense budget includes all the operating outlays of the Soviet military establishment. [128]

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128 Op. Cit., Robert E. Leggett and Sheldon T. Rabin, "A Note on the Meaning of the Soviet Defense Budget," pages 14-17 (underling added for highlighting purposes).

The foregoing Leggett/Rabin hypothesis may be statistically tested when the CIA's data set for X and Y for the period 1960-1970 is obtained and when the $\bar{X}_*$, σ_ε^2, a, b, and σ_{x*}^2 parameters required to implement Equations (25) and (26) are estimated. In this context, their alternative hypothesis is that $\alpha_{7t}>1$. Additionally, the CIA estimates of $\tilde{\alpha}_{7t}$ in Column 8 of Table 2.16 for the period 1971-1975 can be used for α_t^* in Equation (26) to test the following alternative null hypotheses:

- The first alternative null hypothesis is that the French and CIA estimates of the Soviet Operating Budget are statistically different, which can be tested by allowing the French estimates of $\tilde{\alpha}_{6t}$ in Column 6 of Table 2.16 to be the numerical implementation of α_t in Equation (26). This test corresponds to the null hypothesis that $\alpha_t<1$ for the forecast period which should be readily rejected on the basis of the Leggett/Rabin non-statistical hypothesis previously described.
- The second alternative null hypothesis is that Stanley Cohn's (i.e., official defense budget) and the CIA estimates of the Soviet Operating Budget are statistically different, which can be tested by setting $\alpha_t=1$ in Equation (26). In this case, as previously observed, Robert Leggett and Sheldon Rabin believe that "the gap...becomes greater over time..., however, the differences by themselves are probably not substantial enough to reject the (null) hypothesis". Inasmuch as Equation (26) provides a means of testing the null hypothesis for each year between 1971 to 1975, it therefore permits the determination of that particular year in which the second null hypothesis can be rejected--which is a much more rigorous basis for ascertaining exactly when the "increasing gap" becomes statistically significant.
- The third alternative null hypothesis is that Bill Lee's and the CIA estimates of the Soviet Operating Budget are statistically different, which can be tested by allowing Bill Lee's estimates of $\tilde{\alpha}_{5t}$ in Column 7 of Table 2.16 to be the numerical implementation of α_t for the period 1971-1975 in Equation (26). Although this null hypothesis is not emphasized by Leggett and Rabin, estimates of $\tilde{\alpha}_{5t}$ in Column 7 of Table 2.16 do reflect an arbitrary revision in the estimating methodology as previously introduced in Footnote 52. Therefore, it is important to determine the 95 percent confidence interval associated with the CIA estimates of $\tilde{\alpha}_{7t}$ in Table 2.16 for the period 1971-1975 by implementing Equation (26). In this context, other estimating methodologies which provide alternative estimates that are "too low" (i.e., the French and Stanley Cohn estimates) or are "too high" (i.e., Bill Lee's estimates) will be "significantly different" for those years that they are <u>not</u> contained within the CIA 95 percent confidence interval. The empirical implementation of these alternative hypotheses and confidence intervals is considered a suitable subject for future research.

The French estimates of Soviet NSE for the period 1971-1975 are summarized in Table 2.17 by major categories of expenditure.

Table 2.17

French Estimates of Soviet National Security Expenditures [129]
(billions of current rubles)

1	2	3	4	5	6	7	8
	Investment Expenditures			Operating Expenditures			
Year	Soviet Procurement Expenditures (Y_{6t})	Military R&D Expenditures a_{5t}(Science)$_t$	Total Procurement and Military R&D Expenditures	Personnel Costs (Compensation)	Non-Personnel Costs (Operations and Maintenance)	Estimate of the Soviet Operating Budget a_{5t}(Defense)$_t$	Total Estimated Soviet NSE (D_{5t})
1960							21.6*
1961							22.6*
1962							23.6*
1963							24.7*
1964							25.9*
1965							27.4*
1966							28.3*
1967							29.6*
1968							31.0*
1969							32.4*
1970							33.9*
1971	16.1	7.6	23.7	8.2	3.5	11.7	35.4
1972	16.1	9.0	25.1	8.4	3.5	11.9	37.0
1973	17.9	9.6	27.5	8.6	3.6	12.2	39.7
1974	17.8	10.3	28.1	8.8	3.7	12.5	40.6
1975	18.5	11.7	30.2	9.0	3.8	12.8	42.3

[129] Sources of information presented in Table 2.17 are as follows:

- Column 2 is taken from the previously cited article in Defense Nationale on "How Many Rubles for Defense?", Table 3, page 35.
- Column 3 is two-thirds of the "old series" for Science which is about three-fifths of the "new series" for Science provided in Table 2.1--except for the year 1975 where the two-thirds rule applies. The French methodology is clearly based upon "the arbitrary but widely accepted assumption that two-thirds of the scientific research outlays are allocated to projects of military interest" (Defense Nationale article, page 34). However, the scope of the Science entry in the N.Kh. handbooks has recently been changed, which requires an upward revision of about one billion rubles in the French estimates. A comparison of the "old series" and the "new series" for Science is provided in Bill Lee's book, Table D.13, pages 288-289.
- Column 4 is Column 2 plus Column 3.
- Column 5 is Column 3 of Table 2.16.
- Column 6 is Column 4 of Table 2.16.
- Column 7 is Column 5 plus Column 6.
- Column 8 is Column 4 plus Column 7, but the entries with the asterisks for the period 1960-70 reflect a curvilinear "backcasting" using the estimated average growth rate by means of least squares for the period 1971-1975. The projection equation is $z_t=(35.4)(1.046)^{t-1971}$ for t=1960,.... 1970.

2.8 THE DIRECT COSTING TECHNIQUE

The seventh baseline methodology for estimating Soviet NSE is the Direct Costing Technique of the CIA. Although the Strategic Cost Analysis Model (SCAM) associated with this technique is documented in such references as

- Estimated Soviet Defense Spending: Trends and Prospects (SR-78-10121), June 1978,
- Estimated Soviet Defense Spending in Rubles, 1970-1975, (SR-76-10121U), May 1976,
- Methods for Estimating the Costs of Soviet Defense Activities, (SR-M 77-10008), December 1976,
- Methods for Estimating Soviet Defense Expenditures, (SR-M 76-10272C), April 1977, and
- A set of computer-based files of working-level, methodological statements,

only the first two of these five references are unclassified. However, these documents provide the following general insight into CIA's direct costing methodology:

> Because of the lack of meaningful official data, we provide alternative estimates of Soviet defense activities in both dollar and ruble terms. Both estimates begin with the detailed identification and listing of the physical components and activities which make up the Soviet defense program for a given year. By a variety of methods, this physical data base is converted into two aggregates, one denominated in rubles, the other in dollars. For some components, such as military personnel costs, the physical data are costed directly, using available ruble prices and costs and dollar prices and costs. For others, conversions are made from one value base to the other by applying dollar-to-ruble and, to a much more limited degree, ruble-to-dollar ratios which reflect the estimated relative efficiency of the Soviet Union and the U.S. in a particular activity.[130]

The recent revisions in CIA estimates of Soviet NSE concerned only its ruble estimates, not its dollar estimates, which are explained as follows:

> For its dollar estimates of Soviet defense activities, the CIA uses a building-block technique which involves costing in dollars its own intelligence assessments of the physical size of Soviet Armed Forces. In theory, these estimates represent the cost to the United States of reproducing the Soviet defense effort, but in practice they do not do so in two major areas:

[130] CIA, SR-76-10121U, page 5.

First, Soviet Research, Development, Testing and Evaluation (RDT&E) is determined by taking a percentage of the financial resources allocated to 'Science';

Second, when intelligence on certain Soviet weapons or operating techniques is incomplete, a similar American system or practice, adjusted for known Soviet features, is costed instead.

Suitable conversion rates are then prepared to convert these dollar estimates to rubles. Official dollar-ruble exchange rates, since they do not accurately reflect the purchasing power of foreign currencies vis-a-vis the ruble, are unsuitable for this. New information on the efficiency, or otherwise, of Soviet industries has led the CIA to revise its previous conversion rates to give more rubles per dollar. The ruble measurement of Soviet defense spending is intended to reflect a Soviet valuation of the resources foregone in producing the defense effort, to the extent that it is possible in a totally planned economy, and is therefore suitable as a method for calculating burden. The doubling of CIA ruble estimates merely reflects a change in conversion rates, so the dollar estimate has remained the same. 131

As indicated by the late John Paisley, CIA's methodology for estimating Soviet NSE is much more complicated than the mere estimation of the parameters in generic Equation (1).[132] However, in order to facilitate comparisons with other less complicated baseline methodologies, the basic assumptions for substitutions in Equation (1) are as follows:

$$\begin{aligned} &\alpha_{7t} \leq 1 \text{ for } t=1960,\ldots, 1970 \text{ and } \alpha_{7t} > 1 \text{ for } t=1971,\ldots, 1975,\\ &\beta_{7t} \simeq 2/3 \text{ over the } t=1960,\ldots, 1975 \text{ period,}\\ &\gamma_{7t} = \text{the direct costing of Soviet military programs, and}\\ &\delta_{7t} = 0. \end{aligned} \tag{27}$$

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131 International Institute for Strategic Studies, The Military Balance, 1976-1977, London, England, page 109.

132 Appendix D, pages D-15 and D-17 to D-19.

2.8.1 Quantity and Quality of Soviet Defense Goods and Services

In order to better explain CIA's revisions of its estimation of Soviet NSE, generic Equation (1) may be reformulated as follows:[133]

$$D_{7t} = \sum_{i=1}^{i=n} Q_{it}P_{it} = \sum_{i=1}^{i=n} Q_{it}^{USSR}P_{it}^{US}\ (r/\$\ ratio)_{it} + \delta_{7t} \qquad (28)$$

> where Soviet defense spending may be conceptually disaggregated into N physical quantities of additional goods and services (Q_{it}) procured at prices (P_{it}) in the time period t.

This conceptual reformulation must be implemented by a physical count of Soviet military goods and services (Q_{it}^{USSR}) at the US prices required to replicate Soviet technical and performance specifications (P_{it}^{US}) and converted from dollars to rubles by means of estimated ruble/dollar ratios $(r/\$\ ratio)_{it}$. The dollar estimates of Soviet defense spending by means of the CIA direct costing methodology may be expressed as follows:

$$D_{7t}^{\$} = \sum_{i=1}^{i=n} Q_{it}^{USSR}P_{it}^{US} \qquad (29)$$

while the rubles estimates of Soviet NSE may also be expressed as follows:

$$D_{7t}^{r} = \sum_{i=1}^{i=n} Q_{it}^{USSR}P_{it}^{US}\ (r/\$\ ratio)_{it} \qquad (30)$$

If the actual error in the CIA estimating methodology is limited to underestimation of the $(r/\$\ ratio)_{it}$ term in Equation (30), then the dollar estimates in Equation (29) will not be affected--only the ruble estimates of Soviet NSE will be underestimated which, as recently observed by Professor Abram Bergson of Harvard University, will have the following implication:

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[133] The error term δ_{7t} will be zero only if all SIPRI categories in Table 2.0 are included in the Q_{it}^{USSR} observations (i.e., no information error) and if all $P_{it}^{USSR} = P_{it}^{US}\ (r/\$\ ratio)_{it}$ (i.e., no methodology error).

> My immediate reaction is that we could analyze Soviet capabilities without reference to ruble figures. We have the physical data. If we wanted to aggregate, we could do so in terms of dollars and make comparisons. But when you get into questions like defense burden, competing uses of resources in the Soviet Union from the standpoint of the Soviet government, you have to introduce rubles.[134]

Therefore, by revising the ruble/dollar ratios upward, the estimated defense burden increased--which has important implications for resource allocation.

However, it is also possible that the prices (P_{it}^{US}) and quantities (Q_{it}^{USSR}) are understated which would affect the dollar estimates in Equation (29). If the estimates of $(r/\$ \text{ ratio})_{it}$ are revised in a base year, such as 1970, so as to adjust the ruble estimates when revisions in P_{it}^{US} and Q_{it}^{USSR} are actually required, then such a methodology error will understate the ruble estimates in Equation (30) over time beyond the base year. Therefore, the new information for the base year 1970 resulted in the announced revision of the ruble estimates. However, if the foregoing methodology error were not properly corrected, then an unrealistic, continuous acquisition of new information would be required in order to obtain correct ruble estimates each year. Otherwise, the methodology error would bias both the trend and the level of the ruble estimate (D_{7t}^{r}) in Equation (30)--which, as observed by Steven Rosefielde, would have the following significant national security implications:

> If we are correct that an error was made in 1970--that Soviet defense expenditures in rubles are much greater than we thought they were and that this can't be rationalized in terms of a ruble/dollar ratio--then the question we have to ask is: where is the error? If it's not in the ruble/dollar ratio as a mere monetary phenomenon, then where can it be? I would like to suggest that it can be in either of two places: 1) in the weapons count or, 2) in the quality of the weapons...What I know about the weapons count makes me somewhat suspicious. You send a satellite up; you see a factory; you measure the number of square feet in the factory; and you try to figure out how many weapons are produced inside that factory. I'm a little

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134 Appendix D, page D-39.

> doubtful with regard to the accuracy of such estimates. But, regardless of that particular point, what about quality? Over time, as everyone knows, the quality of Soviet military hardware has improved so that, if defense goods are computed with base year equipment unadjusted for quality change, a mere physical inventory of Soviet weapons may seriously understate the real volume of effective Soviet weapons. At the same time, dollar and ruble costs are understated by failing to measure the true volume of primary inputs needed for their production.[135]

The quality of the Soviet weapons is embodied in the prices P_{it}^{US}, which should reflect all of the Soviet physical characteristics and technological parameters. The quantity of the Soviet weapons (Q_{it}^{USSR}) is based upon samples of direct observations, and a set of Cost Estimating Relationships (CER) is used to determine the dollar cost of a given weapon system which, ideally, establishes the "opportunity cost" price P_{it}^{US} for each Q_{it}^{USSR}. However, this "ideal price" is seldom realized for the following reasons:

> The dollar costs of Soviet weapons systems fall into three general categories, depending upon the intelligence information and the amount of cost-analyst time available.
>
> - First, some Soviet weapon systems are assigned the cost of the most comparable U.S. system, without attempting to take into account differences in characteristics and performance parameters.
> - Second, CERs are used for various components and subsystems. For example, the dollar cost of a Soviet missile may be constructed from a family of CERs for the various subsystems and components: airframe, propulsion, guidance and control, RV, warhead.
> - Third, an actual Soviet weapons system, or a complete set of system characteristics and performance parameters, are turned over to a U.S. company with experience in that type of system for a detailed analysis of what it would cost the U.S. company to produce the Soviet hardware at some specified quantity.

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[135] Appendix D, pages D-27 and D-28 (underlining added for highlighting purposes).

> The third type of dollar costing is preferred, but it is the least prevalent, since copies of Soviet systems and detailed specifications become available only for a few systems and then infrequently. Dollar costs constructed from component CERs are the next most favored, probably the most widespread approach. The simple US analogue dollar cost is the least desirable approach, but it often is the best that can be done with the information available.
>
> Complex weapons systems tend to be mixtures of the first two types of costs: some component costs are estimated from CERs, while others are simple analogues or percentage factors added in an attempt to arrive at total system costs. Only rarely does the information permit a complete weapons system cost analysis by an experienced manufacturer because the United States has seldom acquired a complete Soviet weapons system intact.[136]

Therefore, it is important to obtain ruble estimates of Soviet defense spending not only to examine resource allocation issues such as the defense burden, but also to provide a "consistency check" on the dollar estimates in Equation (29). If the quality and quantity measurements are in error, then alternative methodologies for obtaining ruble estimates of Soviet NSE can be used to evaluate the CIA ruble estimates in Equation (30) for bias in both trend and level. Consequently, it is useful to examine the disaggregation of CIA's ruble estimates based upon the general classifications embodied in the assumptions presented in Equation (27).

2.8.2 Principal Resource Categories

As described in the previously cited, unclassified CIA report pertaining to the SCAM, the CIA's ruble estimates may be disaggregated into the following "three principal resource categories":

> Another way of analyzing Soviet defense spending is to break it down into three principal resource categories--investment, operating, and RDT&E. Since 1970, each of these categories has accounted for about the same portion of the total. Investment outlays and operating requirements have each taken about 40 percent, while some 20 percent has been devoted to RDT&E.

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136 Op. Cit., The Estimation of Soviet Defense Expenditures, 1955-75: An Unconventional Approach, pages 8-9.

Investment. Defense investment, which includes procurement of weapons and equipment and construction of facilities, reflects the flow of new equipment into the forces. The composition of investment spending also sheds light on the forces' technological level.

Most investment spending, and about one-third of total defense spending, is for new weapons. During 1970-1975, about 45 percent of the total weapon procurement outlays was for strategic weapons. About 70 percent of total expenditures for weapons procurement was devoted to purchases of aircraft and missiles. This reflects both the emphasis the Soviets are putting on modernizing their forces with such systems and the fact that these items are extremely costly.

Procurement of equipment for support of deployed forces--such as radar and other electronic systems, general purpose vehicles, a wide array of organizational equipment, and military space reconnaissance systems--has increased steadily. Outlays for construction of facilities have accounted for about 10 percent of total investment costs during the period.

Operating. Operating expenditures are those costs associated with the day-to-day functioning of the military establishment. The major factor in operating costs is military manpower. In 1970-1975, personnel costs--pay and allowances, food, and personal equipment--accounted for a little less than half of total operating outlays and about 20 percent of total defense expenditures.

Maintaining the stocks of weapons and equipment required about 35 percent of operating expenditures. These outlays are primarily for the purchase and installation of spare parts. Over the past decade they have been growing almost twice as fast as personnel expenditures, and faster than overall defense spending. This is an indication of the increasing size and complexity of Soviet weapon holdings.

The remainder of operating expenditures--maintenance of facilities, purchases of petroleum and lubricants, utilities, transportation, and other general operating items--accounts for less than 10 percent of total defense spending.

RDT&E. The estimate of Soviet outlays for RDT&E is based primarily on analysis of Soviet statistics and is the least reliable of our estimates. There is considerable uncertainty about the basic data, most of which come from Soviet publications. In addition, the estimate of the division of expenditures between the military and civilian sectors is particularly

> uncertain. Despite the limitations of the specific data, what we know in general about Soviet military research programs indicates that spending for military RDT&E almost certainly increased between 1970 and 1975. The majority of Soviet RDT&E funds probably were directed toward the development of strategic systems. Moreover, the growing complexity of modern weapons will require increasing allocations for the development of future generation.[137]

In addition to the foregoing CIA definitions of major resource categories, the division of estimated Soviet RDT&E expenditures between the military and civilian sectors has been explained by CIA economist, John Pitzer, as follows:

> R&D is very heavily military. Total expenditures are estimated in 1970 as 9.927 billion rubles. Estimates of military R&D range from 50% to 75% of total R&D. The Soviet published value (Science) on which the 9.927 billion rubles is based, is thought to be understated by about 30%. Thus, if we increase this total by 30% and take an intermediate share of 60%, military R&D would be about 7.5 billion rubles.[138]

The rather complicated algorithm reflected in this statement is still consistent with the "two-thirds rule" with respect to the Science line item because the 1970 entry for Science in Table 2.1 is 11.7 billion rubles. In other words, the CIA estimate of 7.5 billion rubles for Soviet military R&D in 1970 is a little less than two-thirds of the 11.7 billion rubles. This is also consistent with the assumption that $\beta_{7t} \simeq 2/3$ in Equation (27). Moreover, the ratio ($\tilde{\alpha}_{7t}$) of CIA's estimate of the Soviet Operating Budget to the Official Soviet Defense Budget in Column 8 of Table 2.16 is consistent with the assumption pertaining to α_{7t} in Equation (27).

2.8.3 CIA Estimates of Soviet NSE

CIA estimates of Soviet NSE utilizing the Direct Costing Technique are summarized in Table 2.18. It should be noted that the CIA estimates of the Soviet Operating Budget in Column 2 of Table 2.18 do not include expenditures for military construction which appear in Column 5 and are included in the

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137 CIA, Estimated Soviet Defense Spending in Rubles, 1970-1975 , SR 76-10121U, May 1976, pages 13-14.

138 John Pitzer, "Reconciliation of Gross National Product and Soviet National Income" a paper presented at a NATO colloquium in July 1977, CIA Office of Economic Research, December 1977, page 28.

Table 2.18

CIA Estimates of Soviet National Security Expenditures for the Period 1960-1975 [139] (billions of current rubles)

1	2	3	4	5	6	7
	Operating Expenditures		Investment Expenditures			
Year	Operating Budget Estimate α_{7t}(Defense)$_t$	Military R&D Expenditures β_{7t}(Science)$_t$	Soviet Procurement Expenditures	Soviet Military Construction Expenditures	Total Soviet Investment Expenditures (γ_{7t})	Total Estimated Soviet NSE (D_{7t})
1960	9.0	4.6 (2.6)	8.1	.9	9.0	22.6
1961	9.6	4.9 (3.0)	8.7	.9	9.6	24.1
1962	10.3	5.1 (3.5)	9.3	1.0	10.3	25.7
1963	10.9	5.5 (3.8)	9.8	1.1	10.9	27.3
1964	11.7	5.8 (4.2)	10.5	1.1	11.6	29.1
1965	12.4	6.2 (4.6)	11.2	1.2	12.4	31.0
1966	13.2	6.6 (5.0)	11.9	1.3	13.2	33.0
1967	14.1	7.0 (5.5)	12.7	1.4	14.1	35.2
1968	15.0	7.5 (6.0)	13.5	1.5	15.0	37.5
1969	16.0	7.9 (6.7)	14.4	1.6	16.0	39.9
1970	17.0	8.5 (7.8)	15.3	1.7	17.0	42.5
1971	18.1	9.1 (8.7)	16.3	1.8	18.1	45.3
1972	19.3	9.6 (9.6)	17.3	2.0	19.3	48.2
1973	20.6	10.2 (10.5)	18.5	2.1	20.6	51.4
1974	21.9	10.9 (11.0)	19.7	2.2	21.9	54.7
1975	23.3	11.6 (11.7)	20.9	2.4	23.3	58.2

[139] Sources of information presented in Table 2.18 are as follows:

- Column 2 is 40 percent of Column 7;
- Column 3 if 20 percent of Column 7--for purposes of comparison, the figures in parentheses are 2/3 times the values of the Science line item in Table 2.1;
- Column 4 is 36 percent of Column 7;
- Column 5 is 4 percent of Column 7;
- Column 6 is Column 4 plus Column 5 or 40 percent of Column 7; and
- Column 7 is derived from the methodology developed in Tables 2 and 3 of Leggett/Rabin's article on "A Note on the Meaning of the Soviet Defense Budget", in Soviet Studies. The curvilinear projection equation for the mid-point values of the interval estimates is: $z_t = (42.5)(1.065)^{t-1970}$ for t=1960,..., 1975. The two basic assumptions used for this projection are: 1) the 1970 base year figure can be "backcasted" to 1960 "using a 4-5 percent annual growth rate", and 2) the original CIA estimates in 1970 rubles can be "adjusted conservatively for a 2 percent annual rate of inflation".

estimates of total Soviet Investment Expenditures in Column 6.[140] Although the estimates of Soviet military R&D expenditures in Column 3 of Table 2.18 are approximately 20% of the figures in Column 7 and roughly two-thirds of the Science line items in Table 2.1 (which are shown in parentheses) for the period 1970-1975, there is a distinct divergence between the estimates in Column 3 and the two-thirds of Science line items in parentheses for the period 1960-1970.[141] As may be observed by comparing the entry in Column 3 for 1960 with two-thirds of the Science line item for the same year in Table 2.1, the magnitude of what appears to be a methodology error is two billion rubles (i.e., 4.6 - 2.6 = 2.0).[142]

Comparison of alternative estimates of the parameter α_t in Table 2.18 by means of the statistical confidence interval in Equation (26) provides a test for any significant differences in the methodologies for estimating the Soviet Operating Budget. The same test may also be used to determine whether there is a significant difference in the definitions for the component elements of the Soviet Operating Budget which Bill Lee has defined as follows in terms of Soviet operating costs:

> Operating costs are defined as a) personnel costs (pay and wages of uniformed and civilian personnel; food, clothing, and medical supplies and services); b) operating costs (all fuel, power, chemicals, spare parts, and water: materials and services required for current operation and maintenance of the MoD establishment, other than personnel costs); c) capital repair of facilities and equipment; d) military construction; and e) official travel.[143]

[140] Column 2 of Table 2.18 corresponds to SIPRI categories 1, 2, and 3 in Table 2.0, while Column 3 corresponds to SIPRI category 5, Column 4 to SIPRI category 4, and Column 5 to SIPRI category 6.

[141] It is possible that the curvilinear projection of the total estimated Soviet NSE for the period 1960-1970 results in an overestimate of actual defense spending by the difference between the values in Column 3 with and without parentheses. However, as discussed in Appendix A, this divergence is resolved in favor of the "two-thirds of Science" rule.

[142] Robert Leggett and Sheldon Rabin are able to test the quality of their projected estimates of the CIA Operating Budget by comparison with the Official Soviet Defense Budget reflected in Table 2.7. The estimates utilizing the "two-thirds of Science" rule in Column 3 of Table 2.18 provide the same type of quality test for the estimates utilizing 20 percent of D_{7t}.

[143] Op. Cit., Bill Lee's book, page 36.

It is evident that Bill Lee considers military construction to be an operating cost, whereas the CIA considers it to be a defense investment expenditure. Bill Lee explains the basis for his definition of operating costs as follows:

> It seems to be rather common knowledge amongst emigre Soviet economists that the "Defense" appropriation finances wages of personnel, operating costs (all types of material purchases), amortization (replacement, poteri) of facilities and equipment, military construction, and official travel. According to these sources, the reported "Defense" appropriation in the USSR State budget does not include the cost of military hardware (voennia teknika), prototypes for military R&D programs, or hardware expended for civil and military space programs. This information is fully consistent with (the viewpoint that) "Defense" consists of the standard Group II articles, which would cover only pay, operations, maintenance, and military construction. This is not to say that "Defense" covers all such outlays by the MoD, but that "Defense" covers only such outlays.[144]

The "common knowledge amongst emigré Soviet economists" cited by Bill Lee apparently reflects a private communication between Bill Lee and "a Soviet economist who worked in the economic research institute of the USSR Academy of Sciences", because Bill Lee's definition of operating costs is identical to what this emigré Soviet economist told him constitutes the "Defense" appropriation.[145] By contrast, Robert Leggett and Sheldon Rabin of CIA provide the following alternative definition of the Soviet Defense Budget:

> It is suspected that the announced defense budget covers only the operating and maintenance costs of the Soviet military establishment. This notion is prompted by a review of several Soviet monographs which imply--if we follow them to their logical conclusions--that the official defense appropriation during the postwar period has been a current expenditures budget for the Ministry of Defense. Although no definitions are provided in the Soviet literature, this kind of budget would likely include pay and allowances of military personnel, wages of civilian MoD employees, some current repair of facilities, food and nonfood quartermaster supplies, utilities and the like. Under this concept, expenditures for the procurement of

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[144] Ibid., page 328. The "Defense" appropriation reflects the value of the Official Soviet Defense Budget provided in Table 2.1.

[145] William T. Lee, "Hidden Defense Expenditures in the USSR State Budget," GE-TEMPO working paper (GE 75 WP-14), 1975, page 27.

weapons, military space programs, R&D, and other defense activities would be financed elsewhere in the State budget (primarily under Financing the National Economy and Science) or possibly financed from non-budgetary sources.[146]

Therefore, in order to avoid the introduction of an "information error", it is necessary either to use the same definition of Soviet operating costs or to develop a new estimate of the Operating Budget parameter (α_7) in Table 2.16 using the CIA data in Table 2.18 and Bill Lee's definition of operating costs. This requires that the military construction expenditures in Column 5 of Table 2.18 be added to the CIA estimates of the operating budget in Column 2 of the same table. The resulting sum is then divided by the official Soviet Defense Budget in Table 2.16 to obtain new CIA estimates of the α_t parameter--which are summarized in Table 2.19.

The new CIA estimate ($\tilde{\alpha}^*_{7t}$) in Column 6 of Table 2.19 is generally greater than the Bill Lee's estimate ($\tilde{\alpha}_{5t}$) in Column 8 of the same table. Inasmuch as Bill Lee's sets of data for X and Y in Columns 6 and 7 of Table 2.7 for the period 1960-1970 (as modified in Footnote 126) can be used to estimate the $\bar{X}_*$, σ^2_ε, a, b, and σ^2_{X*} parameters for Equations (25) and (26), the statistical significance of *the CIA estimating methodology* may then be tested. The new CIA estimate in Column 6 is based upon the same definition as that used by Bill Lee, so that differences between $\tilde{\alpha}^*_{7t}$ and $\tilde{\alpha}_{5t}$ reflect only the differences in the methodologies for estimating the Soviet Operating Budget. By like token, since the new and old CIA estimates in Columns 6 and 7 of Table 2.19 (i.e., $\tilde{\alpha}^*_{7t}$ and $\tilde{\alpha}_{7t}$) are based upon the same estimating methodology, then the differences between them reflect only the differences in the definitions of the Soviet Operating Budget. In this context, Robert Leggett and Sheldon Rabin cite such Soviet authors as V.P. V'yachenk, L. Ya. Berri, and V.A. Yevdokimov, as well as Milan Scicak (Varmade po unoru, Prague, 1968, page 154) to support their view that the Soviet Defense Budget does not contain military construction expenditures. Although most of this evidence with respect to the correct definition of the Soviet Operating Budget appears to be inconclusive, the foregoing statistical test may be used to determine the importance

[146] Op. Cit., Robert Leggett and Sheldon Rabin, "A Note on the Meaning of the Soviet Defense Budget," page 9. In Footnote 8, the authors acknowledge that "Other plausible variations of the operational budget hypothesis are certainly possible. William Lee, for example, has written that the defense budget... probably has consisted entirely of operating costs and military construction in most, although not all, years since the early 1950s". (Op. Cit., Bill Lee's book, 1977, page 278).

Table 2.19

New CIA Estimates of the Parameter α_t [147]

1	2	3	4	5	6	7	8
Year	Official Soviet Defense Budget $(\text{DEFENSE})_t$	The CIA Estimates of Operating Budget (Original Definition)	The CIA Estimates of Military Construction Expenditures	CIA Estimates of the Operating Budget (Bill Lee's Definition)	New CIA Estimate $(\tilde{\tilde{\alpha}}^*_{7t})$	Old CIA Estimate $(\tilde{\tilde{\alpha}}_{7t})$	Bill Lee's Estimate $(\overset{*}{\alpha}_{5t})$
1960	9.3	9.0	.9	9.9	1.064	.968	1.000
1961	11.6	9.6	.9	10.5	.905	.827	.871
1962	12.6	10.3	1.0	11.3	.896	.817	.849
1963	13.9	10.9	1.1	12.0	.863	.784	.820
1964	13.3	11.7	1.1	12.8	.962	.880	.910
1965	12.8	12.4	1.2	13.6	1.062	.969	1.000
1966	13.4	13.2	1.3	14.5	1.082	.985	1.000
1967	14.5	14.1	1.4	15.5	1.068	.972	1.000
1968	16.7	15.0	1.5	16.5	.988	.898	1.000
1969	17.7	16.0	1.6	17.6	.994	.904	1.000
1970	17.9	17.0	1.7	18.7	1.044	.950	1.000
1971	17.9	18.1	1.8	19.9	1.111	1.011	1.078
1972	17.9	19.3	2.0	21.3	1.189	1.078	1.134
1973	17.9	20.6	2.1	22.7	1.268	1.151	1.235
1974	17.6	21.9	2.2	24.1	1.369	1.244	1.312
1975	17.4	23.3	2.4	25.7	1.477	1.339	1.385

[147] Sources of the information presented in Table 2.19 are as follows:

- Column 2 is Column 2 of Table 2.16;
- Column 3 is Column 2 of Table 2.18;
- Column 4 is Column 5 of Table 2.18;
- Column 5 is Column 3 plus Column 4 of this table;
- Column 6 is Column 5 divided by Column 2;
- Column 7 is Column 3 divided by Column 2; and
- Column 8 is Column 7 of Table 2.16.

of these differences. Unfortunately, insufficient information of an unclassified nature is currently available with regard to CIA's estimates of procurement expenditures in Column 4 of Table 2.19 to conduct a statistical test for significant differences in the definitions or estimating techniques of the other baseline methodologies.

2.9 THE EXTERNAL INFORMATION METHOD

The last baseline methodology to be considered in this summary report is the External Information Method, which is based upon recent data published by the Chinese concerning the share of Soviet national income devoted to defense spending. The average annual growth rates for Soviet NSE cited by the Chinese for particular time periods may be used to construct a set of estimates (D_{8t}) for the time period 1960-1975. This external information, which is summarized in Table 2.20, can be used to directly estimate four values of D_{8t}.

Table 2.20

External Information for Estimating Soviet NSE[148]

1	2	3	4	5	6
Year	Share of Soviet National Income Devoted to Defense (D_{8t}/NMP)	Soviet National Income or Net Material Product (NMP)	Estimated Level of Soviet NSE (D_{8t})	Time Period Covered by the Average Annual Growth Rate	Average Annual Growth Rate for Soviet NSE (r_{8t})
1960	.131	142.8	18.7	1961-1965	.090
1970	.171	285.5	48.8	1966-1970	.111
1974	.196	348.2	68.2	1971-1974	.087
1975	.200	363.0	72.6		

[148] Sources of information presented in Table 2.20 are as follows:

- Column 2 is taken from the Peking Review, November 28, 1975, page 9, and November 7, 1975, page 20.
- Column 3 is taken from various issues of Narodnoe Khoziaystvo SSSR, the Soviet annual statistical handbook.
- Column 4 is Column 2 times Column 3.
- Columns 5 and 6 are taken from Peking Review, January 30, 1976, page 11, wherein the average value for r_{8t} during the period 1971-1974 is reported to be .119. However, this is not consistent with the Column 4 data (which probably reflects an arithmetic error) and should be .087 as shown.

By introducing the assumption of "equal annual proportional changes" in the estimates of D_{8t} for those years covered in Column 5 of Table 2.20, then the following curvilinear projection equation may be used:

$$D_{8t} = a_8 b_8^{t-t^*} \quad \text{for } t=1960,\ldots, 1975 \text{ and } t^*=1960, 1965, 1970 \qquad (27)$$

where a_8 is the base year level of D_{8t}, and
$b_8 = (1+r_8)$ is an average growth rate percentage parameter.

In order to calculate the estimates of D_{8t} for the period 1960-1975 using Equation (27) and the data for r_{8t} in Table 2.20, a_8 must initially be set equal to $D_{8,\ 1960}$. As a result, the average growth rate percentage parameter for 1965 is changed from 1.09 to 1.111, and both a_8 and b_8 for 1970 are changed to 48.8 and 1.087, respectively. The estimates of D_{8t} are summarized in Table 2.21.

Table 2.21
Chinese Estimates of Soviet National Security Expenditures[149]
(billions of current rubles)

1	2	3	4	5	6
Year	D_{8t}	Year	D_{8t}	Year	D_{8t}
1960	(18.7)	1966	32.0	1970	(48.7)
1961	20.4	1967	35.5	1971	53.0
1962	22.2	1968	39.5	1972	57.6
1963	24.2	1969	43.8	1973	62.6
1964	26.4			1974	(68.2)
1965	28.8			1975	(72.6)

Since detailed information with regard to the component elements of the estimates of D_{8t} in Table 2.21 are not available, it is not possible to implement the generalized Equation (1). In place of the α_{8t}, β_{8t}, and γ_{8t} parameters for

149 Sources of information presented in Table 2.21 are as follows:

- Column 2 uses a_8 = 18.7 and b_8 = 1.09 from Table 2.20.
- Column 4 uses a_8 = 28.8 and b_8 = 1.111 from Table 2.20.
- Column 6 uses a_8 = 48.7 and b_8 = 1.087 from Table 2.20.

the Soviet Operating Budget, military R&D expenditures, and procurement, the Chinese estimating methodology is reduced to simply the a_8 and b_8 parameters in Equation (27). In this context, the externally supplied information in Table 2.20 may be used with the assumption of "equal annual proportional changes" embodied in the curvilinear projection equation to directly estimate the a_8 and b_8 parameters instead of the α_{8t}, β_{8t}, and γ_{8t} parameters used in the other baseline methodologies. This general relationship may therefore be expressed as follows

$$D_{8t} = a_8 b_8^{t-t^*} = \alpha_{8t}(\text{Defense})_t + \beta_{8t}(\text{Science})_t + \gamma_{8t} \qquad (28)$$

in order to obtain the Chinese estimates of Soviet NSE in Table 2.21. As previously indicated, the δ_{8t} term in Equation (1) is a composite error term which contains a mixture of information error and methodology error that will not necessarily cancel each other to become zero. Therefore, the unknown, but actual, level of Soviet NSE for time period, D_t^*, is related to the Chinese estimates in the following way:

$$D_t^* = D_{8t} + \delta_{8t} = a_8 b_8^{t-t^*} + \delta_{8t} \quad \text{for } t = 1960, \ldots, 1975. \qquad (29)$$

which can be alternatively expressed as:

$$D_{8t} = D_t^* \delta_{8t}^* \qquad (30)$$

where $\delta_{8t}^* = (D_t^* - \delta_{8t})/D_t^* = (1 - \delta_{8t}/D_t^*)$ is a multiplicative composite error term reflecting a mixture of information and methodology errors.

If the actual level of Soviet NSE is hypothesized to follow a curvilinear growth path

$$D_t^* = ab^{t-t^*}, \qquad (31)$$

then substituting Equation (31) into Equation (30) and adding subscripts for the ith estimating methodology will produce the following general formula, which may be used to represent the numerical estimates of Soviet NSE for each of the eight baseline methodologies which have been reviewed in this summary report:

$$D_{it} = a_i b_i^t \delta_{it}^* \qquad (32)$$

In this formula, the a_i and b_i parameters coincide with a and b, respectively, in Equation (31) for all baseline methodologies. In addition, the base year t* may be set to zero (or any desired year) for convenience, and δ^*_{it} must be conceptually partitioned into information and methodology errors.

2.10 PROPERTIES OF ESTIMATORS

Before summarizing the current estimates of Soviet NSE generated by means of the eight baseline methodologies which have been reviewed in this summary report and as an expansion upon the terms of reference previously introduced in Section 2.1 of this report, it should be observed that each of the baseline methodologies may be summarized by means of an estimator which has certain traditional properties. Therefore, it is useful to briefly review:

- Just what is meant by estimation;
- The properties of an estimator;
- The application of estimators in the evaluation of the baseline methodologies and estimates.

In this context, the process of estimation has been described as follows:

> Let us in the first place consider what we mean by "estimation." We know, or assume as a working hypothesis, that the parent population is distributed in a form which is completely determinate but for the value of some parameter θ. We are given a sample of observations $x_1, \ldots, x_n$. We require to determine, with the aid of observations, a number which can be taken to be the value of θ, or a range of numbers which can be taken to include that value.
>
> Now the observations are random variables, and any function of the observations will also be a random variable. A function of the observations alone is called a statistic. If we use a statistic to estimate θ, it may on occasion differ considerably from the true value of θ. It appears, therefore, that we cannot expect to find any method of estimation which can be guaranteed to give us a close estimate of θ on every occasion and for every sample. We must content ourselves with formulating a rule which will give good results "in the long run" or "on the average," or which has "a high probability of success" -- phrases which express the fundamental fact that we have to regard our method of estimation as generating a distribution of estimates and to assess its merits according to the properties of this distribution.[150]

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[150] M.G. Kendall and A. Stuart, The Advanced Theory of Statistics, Hafner Publishing Co., New York, Volume 2, 1961, page 1-2 (underlining added for highlighting purposes).

Furthermore, the difference between an estimator and an estimate may be defined as follows:

> It will clarify our ideas if we draw a distinction between the method or rule of estimation, which we shall call an estimator, and the value to which it gives rise in particular cases, the estimate. The distinction is the same as that between a function f(x), regarded as defined for a range of the variable x, and the particular value which the function assumes, say f(a), for a specified value of x equal to a. Our problem is not to find estimates, but to find estimators. We do not reject an estimator because it gives a bad result in a particular case (in the sense that the estimate differs materially from the true value). We should only reject it if it gave bad results of the estimator were seriously discrepant distribution of possible values of the estimator were seriously discrepant with the true value of θ. The merit of the estimator is judged by the distribution of estimates to which it gives rise, i.e., by the properties of its sampling distribution. 151

The traditional properties of an estimator which are of interest in this summary report may be briefly summarized as follows:

- Consistency,
- The absence of bias,
- Minimum variance,
- Relative efficiency, and
- Sufficiency.

It may therefore be observed that:

- **An estimator which is consistent has the property that, as the sample size of n observations increases, the sampling distribution of the estimate converges to a single value -- the population parameter θ;**
- **An estimator which is unbiased has the stronger property that the mean value of the estimate will coincide with the population parameter θ for any sample size of n observations;**
- **An estimator with minimum variance has the property that its variance formula coincides with a lower bound formula below which the variance of the estimator will not fall;**

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151 Ibid., page 2.

- The relative efficiency of two unbiased estimators can be measured by the ratio of their variance formulas[152]. however, since the mean-square-error of an estimator equals its bias squared plus its variance, then the relative efficiency of any two estimators can be generally measured by the ratio of their mean-square-error formulas;[153]
- An estimator that is a sufficient statistic contains all the information in the sample about the population parameter θ.

It is certainly true that an unbiased and minimum variance estimator must always satisfy the sufficiency property. However, a sufficient statistic need not be an unbiased estimator nor a minimum variance estimator. Consequently, it is possible for an estimator to contain all of the available sample information about the population parameter, but the estimating method or rule formulated is still biased or still inefficient. If this bias does not disappear as the sample size increases, then the estimating method or rule formulated is also inconsistent.

In light of the foregoing properties of an estimator, it may be stated that:

- A methodology error reflects the inappropriate use of all available sample information; while
- *An information error reflects the appropriate use of only part of* the valid sample information, as well as the possible use of erroneous information.

By analogy, a methodology error alone implies that the estimator is a sufficient statistic but may be biased, inefficient, or even inconsistent. By contrast, an *information error alone implies that the estimator is not even a sufficient* statistic. However, once the information error is eliminated, then the estimator would be unbiased, consistent, and have minimum variance. Of course, the usual situation is that an estimator will reflect some unknown combination of both methodology and information errors. As a result, the typical estimator is not a sufficient statistic and is biased, inefficient, and possibly inconsistent. Therefore, the relative intensity of methodology and information errors among the alternative techniques for estimating Soviet NSE does provide a basis for their comparison and evaluation.

152 For example, the mean and median estimators are both unbiased when the parent population is distributed normally. However, since the mean is a minimum variance estimator while the median is not, then the mean is relatively more efficient than is the median.

153 For example, if θ is the population mean, then its mean-squared error is $\sum_{i=1}^{i=n}(X_i-\theta)^2/n$, which equals $(\bar{X}-\theta)^2 + S^2$ where $(\bar{X}-\theta)^2$ is the bias squared and S^2 is the sample variance. The $\bar{X}$ statistic is the sample mean.

2.10.1 Application of Estimators to the Baseline Methodologies

The actual level of Soviet national security expenditures for a given time period (D_t^*) is obviously unknown, but it can be related to the estimated level (D_{it}) by means of the ith estimation technique as follows:

$$D_{it} = D_t^* \varepsilon_{it} \tag{33}$$

where ε_{it} is a stochastic "information error" term.[154]

Assume then that ε_{it} has a lognormal distribution with the following mean and variance:

$$E(\varepsilon_{it}) = \exp(t\mu_i + \tfrac{1}{2}\sigma_i^2) \text{ and } V(\varepsilon_{it}) = \exp(2t\mu_i + \sigma_i^2)\{\exp(\sigma_i^2) - 1\} \tag{34}$$

As a result, the natural logarithm of ε_{it} has a normal distribution with the following mean and variance:

$$E(\ln \varepsilon_{it}) = t\mu_i \text{ and } V(\ln \varepsilon_{it}) = \sigma_i^2 \tag{35}$$

Therefore, the average information error will depend upon the value of the parameter μ_i and the time period t, and the variance of the information error is constant for all time periods.

The actual level of Soviet NSE for a given time period, however, can be conceptually related to a base year (i.e., t = 0) parameter (a_i) and a growth percentage parameter (b_i) using the ith estimation technique as follows:

154 A.S. Goldberger, Econometric Theory, John Wiley and Sons, Inc., 1964, pages 215-216. The assumption of lognormality for ε_{it} is appropriate if the effect of an information error is directly proportional to the magnitude of the actual level of Soviet defense spending (D_t^*). For additional details, see E. Parzen, Modern Probability Theory and Its Application, Wiley, New York, 1960, page 348 and H. Cramer, Mathematical Methods of Statistics, Princeton University Press, 1966, page 220.

$$D_t^* = a_i b_i^t v_{it} \qquad (36)$$

where v_{it} is a stochastic methodology error term.[155]

Assume also that v_{it} has a lognormal distribution with the following mean and variance:

$$E(v_{it}) = \exp(\omega_i + \tfrac{1}{2}\lambda_i^2) \text{ and } V(v_{it}) = \exp(2\omega_i + \lambda_i^2)\,\{\exp(\lambda_i^2) - 1\} \qquad (37)$$

As a result, the natural logarithm of v_{it} has a normal distribution with the following mean and variance:

$$E(\ln v_{it}) = \omega_i \text{ and } V(\ln v_{it}) = \lambda_i^2 \qquad (38)$$

Therefore, the average methodology error depends only upon the value of the ω_i parameter, and the variance of the methodology error is constant for all time periods.

Now, by substituting Equation (36) into Equation (33), the following single operational equation results:[156]

$$D_{it} = a_i b_i^t v_{it} \varepsilon_{it} \qquad (39)$$

If the classical least-squares estimation procedure is applied, the result is

$$\ln D_{it} = (\ln a_i) + (\ln b_i)t + (\ln v_{it} + \ln \varepsilon_{it}) \qquad (40)$$

which yields the following linear estimators:

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155 The particular form specified in Equation (36) applies to all estimation techniques and $b_i = 1 + r_i$, where r_i is the rate of growth. For additional details, see J. Johnston, Econometric Methods, McGraw-Hill, New York, 2nd edition, 1972, pages 48-49. This reflects the hypothesis formulated in Equation (31) wherein the appropriateness of the curvilinear specification will also be reflected in the magnitude of the methodology error term.

156 Equation (39) implements Equation (32) operationally, where $\delta_{it}^* = v_{it}\varepsilon_{it}$ implies a multiplicative decomposition of the composite error term into information and methodology errors.

$$\widehat{(\ln a_i)} = (\ln a_i) + \sum_{t=-n/2}^{t=n/2} (\ln v_{it} + \ln \varepsilon_{it})/n = \left[\sum_{t=-n/2}^{t=n/2} \ln D_{it}\right]/n \qquad (41)$$

$$\widehat{(\ln b_i)} = (\ln b_i) + \sum_{t=-n/2}^{t=n/2} t\,(\ln v_{it} + \ln \varepsilon_{it})/\sum_{t=-n/2}^{t=n/2} t^2 = \left[\sum_{t=-n/2}^{t=n/2} t \ln D_{it}\right]/\sum_{t=-n/2}^{t=n/2} t^2 \qquad (42)$$

The expected (i.e., mean) values of the base year parameter and the growth percentage parameter of the linear estimators in Equation (41) and Equation (42) are, respectively:[157]

$$E(\widehat{\ln a_i}) = (\ln a_i) + \omega_i \quad \text{and} \qquad (43)$$

$$E(\widehat{\ln b_i}) = (\ln b_i) + \mu_i \qquad (44)$$

This suggests that a systematic methodology error (i.e., $\omega_i \neq 0$) in the ith estimation technique will cause a bias in the base year parameter estimator for $\ln a_i$. By contrast, a systematic information error (i.e., $\mu_i \neq 0$) in the ith estimation technique will cause a bias in the growth percentage parameter estimator for $\ln b_i$. The expected value of the estimated level of Soviet NSE may therefore be expressed as follows:

$$E(\ln D_{it}) = E(\widehat{\ln a_i}) + E(\widehat{\ln b_i})t + E(\ln v_{it}) + E(\ln \varepsilon_{it}) \qquad (45)$$

By substituting Equations (35), (38), (43), and (44) into Equation (45), the result is:

$$E(\ln D_{it}) = [(\ln a_i) + (\ln b_i)t] + 2(\omega_i + t\mu_i) \qquad (46)$$

where $2(\omega_i + t\mu_i)$ is the combined bias due to systematic methodology and information errors.

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[157] In Equation (41), the expectation of $\sum_{t=-n/2}^{t=n/2} (\ln v_{iy} + \ln \varepsilon_{iy})/n$ equals $\sum_{t=-n/2}^{t=n/2} (\omega_i + t\mu_i)/n$ using Equations (38) and (35) which reduces to ω_i. In Equation (42), the expectation of $\sum_{t=-n/2}^{t=n/2} t(\ln v_{it} + \ln \varepsilon_{it})/\sum_{t=-n/2}^{t=n/2} t^2$ equals $\sum_{t=-n/2}^{t=n/2} t(\omega_i + t\mu_i)/\sum_{t=-n/2}^{t=n/2} t^2$ using Equations (38) and (35) which reduces to μ_i.

In order to further evaluate the variance formulas for the linear estimators defined in Equations (41) and (42), some additional questions with regard to the methodology and information errors terms (i.e., v_{it} and ε_{it}, respectively) must be addressed. For example, are these terms independent for the ith estimation technique, or are these systematic errors interdependent? The minimum variance and relative efficiency properties of the alternative estimators depend upon the answers to these crucial questions. Since a biased estimator (whose magnitude of bias is independent of the sample size) will not be consistent, then Equations (41) and (42) represent inconsistent linear estimators.[158] Moreover, if μ_i equals zero (i.e., there is no information error), then Equation (42) will be a sufficient statistic. In addition, if ω_i equals zero (i.e., there is no methodology error), then an estimator of future Soviet NSE in logarithmic form which is linear, unbiased, consistent, sufficient, and has a minimum variance may be expressed as follows:

$$\ell nD_{it} = (\widehat{\ell na_i}) + (\widehat{\ell nb_i})t \qquad (47)$$

using Equations (41), (42), (46) and the ith estimating technique, because $\mu_i = \omega_i = 0$.

2.10.2 Other Means of Summarizing the Baseline Methodologies

Because most of the foregoing estimators generally require rather tedious and complicated computational algorithms, the generic estimating formula introduced in Equation (1) has provided a more convenient frame of reference for summarizing each baseline methodology in terms of:

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If $E(\ell n\varepsilon_{it}) = (t/n)\mu_i$ in Equation (35) and $E(\varepsilon_{it}) = \exp\left\{(t/n)\mu_i + \tfrac{1}{2}\sigma_i^2\right\}$ in Equation (34), then $(\widehat{\ell nb_i})$ in Equation (42) would still be a biased, but now consistent, estimator. Also, if $E(\ell nv_{it}) = \omega_i/n$ in Equation (38) and $E(v_{it}) = \exp(\omega_i/n+\tfrac{1}{2}\lambda_i^2)$ in Equation (37), then $(\widehat{\ell na_i})$ in Equation (41) would still be a biased, but now consistent, estimator.

- The Operating Budget (α_{it}),
- Military R&D (β_{it}),
- Procurement (γ_{it}), and
- All of the other expenditures (δ_{it}) in Table 2.0.

An even more convenient frame of reference for summarizing the baseline methodologies is the curvilinear growth path estimating formula introduced in Equation (32). By means of this formula, each of the baseline methodologies may be summarized in terms of a

- Base year (i.e., t = 0) parameter (a_i),
- Growth percentage parameter (b_i), and
- Multiplicative composite error term (δ^*_{it}).

It is within this curvilinear growth path frame of reference that δ^*_{it} has been conceptually partitioned into information and methodology error terms (i.e., $\delta^*_{it} = \varepsilon_{it} v_{it}$). Assuming appropriate statistical properties for ε_{it} and v_{it}, respectively, then a systematic methodology error parameter (i.e., ω_i) may be associated with the natural log of a_i and a systematic information error parameter (i.e., μ_i) may be associated with the natural log of b_i. This provides the theoretical framework for introducing a classified value for a_i (i.e., $a_\star$) and alternative hypothesized values for b_i (i.e., $b_\star$) so that each baseline methodology may be statistically evaluated for systematic methodology and information errors.[159] The results of this rigorous <u>statistical evaluation</u> with classified data provide a theoretical framework for future analysis.[160]

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159 The statistical tests are: $t_{\widehat{\ell na_i}} = \dfrac{\widehat{\ell na_i} - E(\widehat{\ell na_i})}{[V(\widehat{\ell na_i})]^{.5}}$ and $t_{\widehat{\ell nb_i}} = \dfrac{\widehat{\ell nb_i} - E(\widehat{\ell nb_i})}{[V(\widehat{\ell nb_i})]^{.5}}$

where the classified value $\ell na_\star$ replaces $E(\widehat{\ell na_i})$ and the alternative hypothesized value $\ell nb_\star$ [i.e., $\ell n(1+r_\star)$] replaces $E(\widehat{\ell nb_i})$ in each t-statistic. The null hupothesis is that $\omega_i = 0$ and $\mu_i = 0$, respectively. Once again, the evaluation of the $V(\widehat{\ell na_i})$ and $V(\widehat{\ell nb_i})$ variance formulas required to implement these t-statistics depends upon whether or not the v_{it} and ε_{it} errors terms for the ith estimating technique are assumed to be <u>independent</u> or <u>interdependent</u>. These theoretical issues provide a focus for future research.

160 The alternative estimating techniques are evaluated in Appendix A within a resource allocation framework by imposing the national income accounts definition of gross national product (i.e., $GNP_t = C_t + I_t + A_t + D_{it}$) using unclassified data. An alternative resource allocation framework for evaluating the various estimating techniques by using the estimates of the rate of growth of Soviet NSE within the Bergendorff-Strangert model is provided in Appendix C.

2.11 A SUMMARY OF CURRENT BASELINE ESTIMATES OF SOVIET NSE

A summary of all of the current estimates of Soviet NSE which have thus far been identified during this review of baseline methodologies is presented in Table 2.22. As may be observed, the

- Historical time period 1960-1975 is partitioned into periods (i.e., 1960-1969 and 1970-1975); and
- Alternative estimates of Soviet NSE are much closer together for the period 1960-1969 than they are for the period 1970-1975 (e.g., the range of alternative estimates of Soviet NSE in 1975 is approximately twice the range in 1970).

Another comparison of the alternative estimates of Soviet NSE may be made by utilizing the Official Soviet Defense Budget, which is uniformly less than all of the other estimates, as a baseline. This comparison, which is summarized in Table 2.23, reflects the:

- Average estimated level of Soviet NSE for each estimating technique over the historical period 1960-1975 divided by the average level of the Official Soviet Defense Budget for the same time period; and
- Degree to which estimated Soviet defense expenditures have been excluded from the Official Soviet Defense Budget, as represented by the ratios shown in Column 4 of the table--for example, it may be observed that:
  - The IISS estimates are about one-and-one-half times the Official Soviet Defense Budget;
  - Stanley Cohn's and the French estimates are about twice the official budget;
  - The SIPRI and Bill Lee's commodity basis estimates are more than twice the official budget;
  - The CIA estimates are almost two-and-one-half times the official budget; and
  - Bill Lee's establishment basis estimates and the Chinese estimates exceed the official budget by more than two-and-one-half times.

A relative ranking of these ratios is presented in Column 5 of Table 2.23, on the basis of which it may be observed that the relative ranking of the:

Table 2.22

A Summary of Current Baseline Estimates of Soviet National Security Expenditures for the Period 1960-1975 159

(billions of current rubles)

1	2	3	4	5	6	7	8	9	10	11
				Revised Budgetary Technique (Stanley Cohn Estimates)		Production Residual Estimation Technique (Bill Lee Estimates)				
Year	Official Soviet Defense Budget	Original Budgetary Technique (IISS Estimates)	FNE and BE Residuals Technique (SIPRI Estimates)	State Reserves Basis	Final Demand Basis	Establishment Basis	Commodity Basis	National Expenditures Method (French Estimates)	Direct Costing Technique (CIA Estimates)	External Information Method (Chinese Estimates)
1960	9.3	11.9	17.2	17.3	18.1	16.0	11.8*	21.0*	22.6	(18.7)
1961	11.6	14.6	18.1	20.3	20.9	18.5	12.9*	22.6*	24.1	20.4*
1962	12.6	16.1	20.9	22.3	22.9	21.0	14.2*	23.6*	25.7	22.2*
1963	13.9	17.8	21.0	23.4	25.5	23.0	15.5*	24.7*	27.3	24.2*
1964	13.3	17.6	21.9	24.5	23.9	24.5	16.9*	25.9*	29.1	26.4*
1965	12.8	17.4	25.0	29.6	23.5	26.0	18.3*	27.1*	31.0	28.8*
1966	13.4	18.4	25.9	28.3	23.7	28.0	22.2*	28.3*	33.0	32.0*
1967	14.5	20.0	26.9	26.8	25.8	32.5	28.3	29.6*	35.2	35.5*
1968	16.7	22.7	31.2	33.4	29.6	38.5	33.5	31.0*	37.5	39.5*
1969	17.7	24.4	33.9	37.1	32.2	42.0	36.8	32.4*	39.9	43.8*
1970	17.9	25.7	38.1	35.4	34.3	46.0	40.2	33.9*	42.5	(48.7)
1971	17.9	26.6	40.7*	38.6	35.7	50.0	43.4	35.4	45.3	53.0*
1972	17.9	27.5	43.6*	35.5	37.3	54.5	48.0	37.0	48.2	57.6*
1973	17.9	28.4	46.8*	38.9	40.2	60.5	53.4	39.7	51.4	62.6*
1974	17.7	28.8	50.3*	39.9	40.3	65.0	57.1	40.6	54.7	(68.2)
1975	17.4	29.1	54.1*	41.8	42.2	71.5	62.3	42.3	58.2	(72.6)
Average Rate of Growth 1960-1969	6.7%	8.3%	7.9%	7.9%	6.6%	11.0%	13.5%	4.6%	6.5%	10.0%
Average Rate of Growth 1970-1975	0.0%	2.5%	7.3%	2.8%	4.2%	9.0%	9.1%	4.6%	6.5%	8.3%
Average Rate of Growth 1960-1975	4.3%	6.1%	7.9%	6.0%	5.8%	10.5%	11.7%	4.6%	6.5%	9.5%
1960 NSE estimated share of the Soviet GNP (184.3 rubles)	.050	.064	.093	.094	.098	.087	.064	.117	.123	.101
Soviet National Security Expenditure Estimate	D_{1t}	D_{2t}	D_{3t}	D_{4t}	D^*_{4t}	D^*_{5t}	D_{5t}	D_{6t}	D_{7t}	D_{8t}

159 Sources of the information presented in Table 2.22 are as follows:

- Column 2 is taken from Table 2.1.
- Column 3 is Column 2 plus two-thirds of the official Soviet Science Line Item in Table 2.1.
- Column 4 is Column 2 plus Column 3 of Table 2.2.
- Column 5 is Column 6 of Table 2.12.
- Column 6 is Column 7 of Table 2.12.
- Column 7 is Column 7 of Table 2.11.
- Column 8 is Column 6 of Table 2.11.
- Column 9 is Column 8 of Table 2.17.
- Column 10 is Column 7 of Table 2.18.
- Column 11 is Column 2, 4, and 6 of Table 2.21.

All entries in this table which are identified by means of asterisks were projected by means of a curvilinear equation as previously explained in the tables cited.

Table 2.23

A Comparison of Alternative Current Baseline Estimates of Soviet National Security Expenditures for the Period 1960-1975 [160]

1	2	3	4	5	6	7	8	9	10	11
ROW	Baseline Methodology Estimates	1960-1975 Historical Period			1960-1969 Epoch Period			1970-1975 Epoch Period		
		Average $\bar{D}_{it}$	Ratio $(\bar{D}_{it}/\bar{D}_{1t})$	Ranking	Average $\bar{D}_{it}$	Ratio $(\bar{D}_{it}/\bar{D}_{1t})$	Ranking	Average $\bar{D}_{it}$	Ratio $(\bar{D}_{it}/\bar{D}_{1t})$	Ranking
1	Official Soviet Defense Budget (D_{1t})	15.2	1.00	10th	13.6	1.00	10th	17.8	1.00	10th
2	IISS Estimates (D_{2t})	21.7	1.42	9th	18.1	1.33	9th	27.7	1.55	9th
3	SIPRI Estimates (D_{3t})	32.2	2.11	5th	24.2	1.77	7th	45.6	2.56	5th
4	Stanley Cohn's Estimates (State Reserves Basis) (D_{4t})	30.8	2.02	7th	26.3	1.93	5th	38.4	2.15	6th
5	Stanley Cohn's Estimates (Final Demand Basis) (D^*_{4t})	29.8	1.96	8th	24.6	1.80	6th	38.3	2.15	7th
6	Bill Lee's Estimates (Establishment Basis (D^*_{5t})	38.6	2.53	2nd	27.0	1.98	3rd	57.9	3.25	2nd
7	Bill Lee's Estimates (Commodity Basis) (D_{5t})	32.2	2.11	4th	21.0	1.54	8th	50.7	2.84	3rd
8	French Estimates (D_{6t})	31.0	2.03	6th	26.7	1.96	4th	38.2	2.14	8th
9	CIA Estimates (D_{7t})	37.8	2.48	3rd	30.5	2.24	1st	50.1	2.81	4th
10	Chinese Estimates (D_{8t})	40.9	2.69	1st	29.2	2.14	2nd	60.5	3.39	1st

[160] Sources of the data presented in Figure 2.23 are as follows:

- Column 3 is $\bar{D}_{it} = \sum_{t=1960}^{t=1975} D_{it}/16$ from Table 2.22.
- Column 4 reflects the result of dividing each row element of Column 3 by the first element in the row (i.e., 15.2).
- Column 5 reflects the ordinal ranking of the elements in Column 4.
- Column 6 is $\bar{D}_{it} = \sum_{t=1960}^{t=1969} D_{it}/10$ from Table 2.22.
- Column 7 reflects the result of dividing each row element of Column 6 by the first element in the row (i.e., 13.6).
- Column 8 reflects the ordinal ranking of the elements in Column 7.
- Column 9 is $\bar{D}_{it} = \sum_{t=1970}^{t=1975} D_{it}/6$ from Table 2.22.
- Column 10 reflects the result of dividing each row element of Column 9 by the first element in the row (i.e., 17.8).
- Column 11 reflects the ordinal ranking of the elements of Column 10.

- IISS estimates is low because the IISS estimating technique assumes that military RDT&E expenditures have been excluded from the Official Soviet Defense Budget, while
- Bill Lee's and the CIA estimates are high because procurement and some operating (in addition to military R&D) expenditures are assumed to have been excluded from the Official Soviet Defense Budget.

As may also be observed in Table 2.23, the relative ranking of the various baseline estimates changes over time as reflected in Column 8 (which is based upon the data in Columns 6 and 7) for the epoch period 1960-1969 and in Column 11 (which is based upon the data in Columns 9 and 10) for the epoch period 1970-1975. For example, during the epoch period 1960-1969, it may be observed that:

- The CIA estimates have the highest relative ranking for the 1960 decade, as reflected in Column 8;
- Stanley Cohn's estimates have a higher relative ranking for this epoch period than for the entire historical period in Column 5; and
- The relative intensity ratios in Column 7 are uniformly lower than those in Column 4 which reflects the significantly lower dispersion of the estimates of Soviet NSE during the first epoch period.

Similarly, during the epoch period 1970-1975, it may be observed that:

- The Chinese estimates have the highest relative ranking, followed by those of Bill Lee and the CIA, as reflected in Column 11;
- The relative ranking of the French estimates for this period reflect the greatest decline when compared to the relative ranking for the first epoch period; and
- The relative intensity ratios in Column 10 are uniformly higher than those in Column 4 which reflects the significantly higher dispersion of the estimates of Soviet NSE during the second epoch period.

A comparison of the relative intensity ratios in Columns 7 and 10 for each estimation technique provides some indication of the increased dispersion in the estimates of Soviet NSE from the first to the second epoch periods. For example, Stanley Cohn's estimates reflect a small increase in the relative intensity ratios as compared to Bill Lee's estimates, which reflect a large increase, and the CIA's, which reflect a moderate increase.

Obviously, the foregoing summary and descriptive evaluation of the alternative baseline estimates of Soviet NSE should be supplemented with a more rigorous statistical evaluation utilizing classified data and additional theoretical research, as outlined in Footnote 159.

3.0 RESOURCE ALLOCATION IMPLICATIONS OF SOVIET NATIONAL SECURITY EXPENDITURES

In this section of the summary report, the resource allocation implications of the baseline estimates of Soviet NSE will focus upon the:

- Problem of production function specification,
- Technology transfer issue, and
- Analysis of the economic burden of Soviet NSE.

3.1 THE SOVIET STRATEGY FOR ECONOMIC GROWTH

Until recently, the Soviet economic system has reflected a classical strategy with respect to economic growth. This strategy has emphasized the maximum rate of mobilization of labor and capital resources for industrial production. Centralized economic planning has enabled the Soviet Government to:

- Generate high rates of investment,
- Transfer millions of workers from agriculture to industry, and
- Attain an impressive rate of economic and industrial growth until the mid-1960s.

During the last decade, the annual increase in the supply of labor has diminished--which is a trend that will continue into the 1980s. Moreover, the agricultural sector no longer provides a large reservoir of labor that can be reallocated to maintain the previous rate of growth of the industrial labor force.[161] A description of this classical growth strategy is provided by Joseph Berliner as follows:

> The classical growth strategy was originally designed for a society in which levels of living were extremely low and the coercive apparatus of the state was overpowering. While monetary incentives have been employed since the inception of the plan period, in the conditions of the time relatively small annual increases in consumption levels were thought to be adequate to the task. Labor discipline was maintained by such

[161] M. Feshbach and S. Rapawy, "Soviet Population and Manpower Trends and Policies," Soviet Economy in a New Perspective, Joint Economic Committee (JEC) report, October 14, 1976, pages 130-134.

coercive means as imprisonment for excessive absenteeism or lateness to work. With the diminution of the extent of coercive controls following the end of Stalin's rule, the incentive system was obliged to bear a greater burden in controlling the behavior of the labor force. The smaller the stick, the larger the carrot has got to be. And indeed, per capita living levels have been increasing steadily in the last two decades, following a long period in which they were virtually unchanged. The shift in the relative importance of coercion and incentives may well have been the beginning of the decline in the potency of the classical growth model, although it was probably not recognized as that at the time. For when the population becomes accustomed to expect increases in income as the reward for effort and risk-taking, the regime is increasingly constrained in the extent to which it can channel resources into investment instead of consumption. The Polish food riot of 1970 is widely regarded as the event that drove home to the leaders of the U.S.S.R. the limits within which they now have to operate in deciding on the distribution of output between investment and consumption.[162]

In addition to the increasing consumption requirements of the Soviet people and as indicated in most of the baseline estimates presented in Table 2.22. The level of Soviet NSE has markedly increased during the period 1960-1975. As a result, the pressures exerted by Soviet consumers and the Soviet military establishment has precluded an increase in the rate of investment (i.e., additions to the capital resource) sufficient to offset the decline in the growth rate of the labor force and to maintain the growth rate in Soviet Gross National Product. In addition, some recent empirical evidence with regard to the estimation of an aggregate Soviet production function suggests that, even if a sufficient increase in the rate of investment were possible, it is becoming increasingly more difficult to substitute capital for labor in the Soviet economy.[163]

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162 J.S. Berliner, "Prospects for Technological Progress," Soviet Economy in a New Perspective, JEC report, October 14, 1977, page 432 (underlining added for highlighting purposes).

163 M.L. Weitzman, "Soviet Postwar Economic Growth and Capital-Labor Substitution," American Economic Review, September 1970, apges 680-682; and also P. Desai, "The Production Function and Technical Change in Postwar Soviet Industry: A Reexamination," American Economic Review, June 1976, Table 2, page 377. A more recent review of this literature is provided by Abram Bergson in his "Notes on the Production Function and Soviet Post-War Industrial Growth," Harvard Institute of Economic Research Discussion Paper Number 650, September 1978.

3.2 PRODUCTION FUNCTION SPECIFICATION

Two widely used production functions which are used to represent Soviet economic growth are illustrated in Table 3.0.

Table 3.0

A Numerical Illustration of the Cobb-Douglas and CES Production Functions [164]

1	2	3	4	5	6	7	8
POINT	Capital Resource (K)	Labor Resource (L)	Cobb-Douglas Production Function (GNP_1)	Constant Elasticity of Substitution (CES) Production Function (GNP_2)	Reduction in GNP Due to Differences in the Elasticity of Substitution ($GNP_1 - GNP_2$)	Capital/Labor Resource Ratio (K/L)	Technological Change Parameter (γ)
A	100	100	100	100	0	1	1.00
B	150	50	87	80	7	3	1.09
C	175	25	66	52	14	7	1.27
D	199	1	14	3.5	10.5	199	4.00

[164] Sources of the information presented in Table 3.0 are as follows:

- Columns 2 and 3 are based upon a numerical example provided by Steven Rosefielde, East-West Trade and Postwar Soviet Economic Growth: A Sectoral Production Function Approach, October, 1976, page 102.
- Column 4 reflects a Cobb-Douglas Production Function: $GNP_1 = \gamma K^{\delta} L^{1-\delta}$ where $\gamma = 1$ is the technology parameter and $\delta = .5$ is the output elasticity distribution parameter. Implicit in this functional form of the GNP production function is a unitary elasticity of substitution between capital and labor resources.
- Column 5 reflects a CES Production Function: $GNP_2 = \gamma[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-1/\rho}$ where $\gamma = 1$ is the technology parameter and $\delta = .5$ is the output elasticity distribution parameter. Explicit in this functional form of the GNP production function is a substitution parameter ($\rho = .5$), which corresponds to an inelastic substitution between capital and labor resources because $\sigma = 1/(1 + \rho) = 2/3$ is less than unity.
- Column 6 is Column 4 minus Column 5.
- Column 7 is Column 2 divided by Column 3.
- Column 8 is Column 4 divided by Column 5.

The four alternative combinations of capital and labor resources are identified as points A, B, C, and D in Column 1 of Table 3.0. The illustrative capital (K) and labor (L) resources in Columns 2 and 3 of Table 3.0 are combined to produce GNP, by means of the Cobb-Douglas production function in Column 4--which implicitly assumes a unitary elasticity of substitution (i.e., $\sigma = 1$) between capital and labor resources.[165] As may then be observed,

- At point A, the levels of capital and labor resources are each equal to 100 units;
- At point B, the capital resource is increased by 50 percent to 150 units and the labor resource is decreased by 50 percent to only 50 units, with the result that GNP_1 in Column 4 declines from 100 units at point A to 87 units at point B--which indicates that more capital must be substituted when there is a 50 percent reduction in the labor force in order to maintain the GNP_1 at 100 units; and
- At points C and D, the increase in the capital resource and the corresponding decrease in the labor resource is 75 percent and 99 percent, respectively, results in a decline in GNP_1 to 66 and to 14 units at points C and D, respectively.

In order to illustrate the effects of reducing the elasticity of substitution between capital and labor resources (σ) to less than unity (i.e., the inelastic resource substitution case) with respect to the GNP, then the more general Constant Elasticity of Substitution (CES) production function must be used. For example,

- When $\sigma = 1$, the CES and Cobb-Douglas calculations are identical, but
- When $\sigma < 1$, the GNP will be less than when $\sigma = 1$, which is illustrated in Column 5 of Table 3.0 where $\sigma = 2/3$, and the lower values of GNP_2 reflect the additional loss in output due to the added difficulties in substituting capital for labor.

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165 By way of further explanation, if capital is increased by 100 percent from 100 to 200 units at point B while labor is decreased by only 50 percent from 100 to 50 units, then $GNP_1 = 100$ units, instead of 87 (as reflected at Point B in Column 3 of Table 3.0). This ratio of the change in capital by 100 units to the change in labor by 50 units to maintain GNP_1 constant is defined as the marginal rate of substitution of capital for labor (i.e., MRS). In other words, the MRS = 2 in order to maintain $GNP_1 = 100$ with a new capital/labor ratio of (200/50) = 4 instead of 3 (as reflected at Point B in Column 7 of Table 3.0). On the other hand, the elasticity of substitution between capital and labor is defined as the percentage change in the capital/labor ratio divided by the percentage change in the MRS.

In other words, the difference between GNP_1 and GNP_2 in Column 6 is a measure of the reduction in GNP when the elasticity of resource substitution is reduced from $\sigma = 1$ to $\sigma = 2/3$. In the limiting case of completely inelastic resource substitution (i.e., $\sigma = 0$), Column 5 would indicate that $GNP_2 = 100$ at point A and $GNP_2 = 0$ at points B, C, and D. Therefore, the closer that σ is to zero, then the greater the loss in output as compared to the case wherein $\sigma = 1$. As may be observed in Column 7 of Figure 3.0, when the capital/labor ratio is 1.0 at point A, there is no difference between GNP_1 and GNP_2 in Column 6. However, as the capital-labor ratio increases at points B, C, and D in Column 7, then the differences between GNP_1 and GNP_2 in Column 6 will result.

Finally, the figures in Column 8 of Table 3.0 indicate the magnitude of the technological change parameter which must be used in the CES production function in order to compensate for a $\sigma = 2/3$, instead of $\sigma = 1$. As the imbalance between the level of capital and labor resources increases (i.e., K/L becomes large), then the productivity effects of new technology must also increase. Therefore, when the capital/labor ratio is 3 at point B, the compensating productivity effects of new technology must be 9 percent. However, when the capital/labor ratio at point C more than doubles to 7, then the compensating productivity effects of new technology must more than triple to 27 percent.

3.2.1 Applications of Production Functions to the Soviet Economy

Application of the foregoing production functions to the Soviet economy is based upon the following three pieces of evidence:

- First, Martin Weitzman estimated that the aggregate value of σ for the Soviet economy is between .274 and .403. However, as indicated in his article cited in Footnote 163, Padma Desai improved upon Martin Weitzman's methodology and estimated σ to be .2771.
- Second, the rate of Soviet investment has <u>not</u> increased to offset the reduction in the growth rate of the labor force but, as described by Joseph Berliner, has actually declined in recent years.

  > The classical (growth) strategy could nevertheless be maintained if the rate of investment could be augmented sufficiently to offset the decline in the growth of the labor force. Far from increasing, however, the growth rate of

investment is also expected to decrease during the next 5 years, and by an astonishingly large amount. Capital investment, the volume of which grew during the last 5 years at the annual rate of 6.9 percent, is scheduled to increase during the next 5 years at only 4.4-4.7 percent. Since the growth rate of investment has been declining for some time, though not at this sharp rate, the growth rate of the capital stock must be expected to decline as well. [166]

- Third, the productivity effects of new Soviet technology has not compensated for the substantial inelasticity of resource substitution (i.e., a σ less than one-half) nor for the lack of sufficient investment to replace scarce labor resources. This situation is also summarized by Joseph Berliner as follows:

  The general conclusion of Western research on Soviet growth is that technological progress has proceeded considerably more slowly there than in the advanced capitalist countries. In the period 1950-1962, for example, in the United States and in all the countries of Western Europe, technological progress was a more important source of growth, and in many cases much more important, than increases in labor and capital inputs. In France, technological progress was the source of 79 percent of the achieved growth of output, while in Italy and Norway it accounted for 78 and 77 percent. In none of the major countries did it fall below 50 percent. In the USSR, by contrast, technological progress accounted for only 42 percent of the growth of output during that period. The USSR alone depended on the classical growth strategy--additions of labor and capital--for over half of its economic growth rate. [167]

  The new appreciation of the significance of technological progress in the promotion of economic growth offered the Soviet leaders an alternative strategy to the increasingly less effective classical strategy. If it was no longer possible to generate new annual supplies of labor and capital at the rate of the past, the rate of economic growth need not decline if the rate of technological progress could be increased. That is, growth would be generated not primarily by more and more machines but by better and better machines. Quality of inputs would substitute for quantity, with no less output resulting, it may be hoped. The classical Soviet growth strategy would be replaced by what may be called the modern strategy.

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[166] Op. Cit., J.S. Berliner, "Prospects for Technological Progress," page 432.

[167] P.R. Gregory and R.C. Stuart, Soviet Economic Structure and Performance, Harper and Row, 1974, page 389. The percentages cited herein were obtained by dividing "output per unit of combined input" (Column 5) by "output" (Column 1) (underlining added for highlighting purposes).

About a decade ago, the Soviet literature began to devote growing attention to the analysis of what is called the scientific-technical revolution. Official pronouncements began increasingly to stress the importance of technological progress in the management and planning of the economy. The Tenth Five Year Plan is the capstone of this trend. Mr. Kosygin has referred to it as the Plan of Quality, a formulation that has been widely picked up and used to encapsulate the main thrust of the plan.

How does one implement a strategy of accelerating technological progress beyond the rates achieved in the past? Two approaches may be identified. One is to import large quantities of foreign technology in those fields in which it is most superior to domestically produced technology. The other is to find ways of augmenting the domestic rate of technological progress beyond that achieved in the past. Both approaches have in fact been adopted.[168]

As illustrated in Column 5 of Table 3.0, Soviet planners are confronted with a situation in which the institutional constraints upon consumption and defense spending prevent sufficient investment expenditures to offset the decline in the growth rate of labor resources. In other words, the production function exhibits substantial inelasticity in resource substitution, so that only significant technological change can resolve the problem of a declining growth rate in GNP_2.

3.3 DEFINITION OF THE TECHNOLOGY TRANSFER ISSUE

Technological change may be the result of domestic research and development efforts, or it may reflect the importation of foreign technology. The importance of international technology transfer to the Soviet economy has been stressed by Philip Hanson as follows:

Soviet policymakers and planners seek Western technology for the obvious reason that the U.S.S.R. is relatively backward in many areas. It has long been common knowledge that there was an East-West civilian technology gap. A systematic general picture of the extent and nature of the Soviet problem, however, is only just beginning to emerge from recent research. Soviet top policymakers

[168] Op. Cit., J.S. Berliner, page 434 (underlining added for highlighting purposes).

themselves have probably begun to grasp many aspects of the problem only over the past fifteen years or so, and this is reflected in policy changes over transfer from the West... The usual view is that there was a more or less abrupt shift at some point in the late 1960s towards a greater emphasis on large-scale commercial imports of Western machinery and know-how; in other words, towards what I have termed "negotiable" technology transfer from the West. Some writers have gone on to argue that this shift in trade policy was a major Soviet motive for seeking détente with the West.[169]

The phrase "technology transfer" must distinguish between vertical transfer between stages of the product cycle and horizontal transfer between places or institutions at a given stage of the product cycle (i.e., the applied research stage, the development stage, or the production stage). International technology transfer is vertical "when Western research results or technical documentation are used in Soviet development and design, or a Western product is treated as a prototype and 'reverse engineered' (copied) for Soviet production".[170] On the other hand, a horizontal transfer of international technology occurs when a chemical plant built in the USSR by a Western contractor incorporates processes already designed into Western plants. Other significant definitions in the discussion of technology transfer are as follows:

- Embodied transfer is the transfer of technology incorporated in design of products, especially machines;
- Disembodied transfer refers to useful technical knowledge transmitted by persons or documents;
- Acquisition transfer involves the transmittal of material and design information with regard to a new technology;
- Assimilation transfer refers to the capacity of an economy to diffuse an imported technology in domestic production processes after it has been acquired;
- Nonnegotiable channels of technology transfer involve the perusal of Western technical literature and patents, industrial espionage and the reverse engineering of single imported machines or components, and occasional visits of scientists, technologists, technicians, and managers; and

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169 Philip Hanson, "International Technology Transfer from the West to the U.S.S.R.," Joint Economic Committee report, Soviet Economy in a New Perspective, October 1976, pages 791-792.

170 Ibid., page 787.

- Negotiable channels of technology transfer which are generally within the control of governments include regular visits by scientists, technologists and others, the training of managers and operators in a foreign country or by visitors from abroad, substantial imports of machinery, licenses, and know-now; and direct foreign investment as well as industrial cooperation. [171]

Reliance upon embodied technology transfer requires support from the domestic research and development (R&D) sector, or it must also be accompanied by some disembodied technology transfer. This resource allocation trade-off between domestic and foreign sources of support in order to assimilate the transferred technology after it has been acquired is described by Philip Hanson as follows:

> If a technology is transferred as know-how, blue-prints, etc. without the actual hardware that embodies that technology, a substantial contribution will probably be needed from the domestic R and D sector before the new product can actually be produced or the new process used.
>
> Buying in the necessary hardware (embodied diffusion) will generally reduce the domestic R and D outputs required, but it will usually have a higher balance-of-payments cost. In the Soviet case, the mix of embodied and disembodied transfer which the planners should choose is therefore likely to vary over time and between sectors of the economy. It should depend upon their assessments of three things:
>
> - the capabilities of their R and D sector in a particular field,
> - the balance of payments, and
> - the prospects for product payback in the industry being considered. [172]

3.4 THE ECONOMIC BURDEN CONCEPT

The concept of the economic burden of Soviet national security expenditures is based upon the principle of opportunity cost. Inasmuch as economic resources are limited, then the allocation of a significant share of the GNP to national security will limit an economy from the standpoint of attaining a

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171 Ibid., page 788.

172 Ibid.

higher level of consumption, or a more rapid growth rate on the basis of investment, or both. In essence, this is the basis for the need to define and develop more credible methods and techniques for estimating the Soviet allocation of resources in its economy. The concept of opportunity cost presumes the full and efficient utilization of resources. In this context, Stanley Cohn has identified the following four possible approaches to the estimation of the Soviet defense burden:

- Comparison of trends in the proportions of GNP devoted to the principal end uses of national product (i.e., consumption, investment, and defense);
- Regression analysis of possible trade-offs between selected defense expenditures and appropriate civilian analogues;
- Analysis of the competing uses of resources, as revealed in an input-output matrix; and
- Determination of possible competitive claims for scarce human inputs.[173]

The first of the foregoing approaches to the analysis of the Soviet defense burden (i.e., the ratio of defense expenditures to GNP) is explored in some detail in Appendix A of this summary report. This methodology is the easiest to implement, but the estimated budgetary costs of defense spending may not coincide with the opportunity costs of Soviet NSE because some costs are implicit (e.g., conscripts absorb some of the actual personnel and maintenance costs that would be otherwise reflected as explicit budget costs in a all-volunteer military manpower system). In addition, Soviet pricing practices do not generally reflect relative scarcities, so the other three approaches to the estimation of the Soviet defense burden must also be considered.

The second approach was used extensively by Stanley Cohn in his paper which is cited in Footnote 173 and will not be reviewed herein. The third approach, which was utilized by Steven Rosefielde in a recent GE-TEMPO draft report,[174] is reviewed in detail in Appendix B of this summary report. In this approach, the input-output analysis of Soviet defense burden is extended

[173] S.H. Cohn, "Economic Burden of Defense Expenditures," Soviet Economic Prospects for the Seventies, Joint Economic Committee report, June 27, 1973, page 147.

[174] Steven Rosefielde, A Preliminary Net Assessment of the Civilian Labor Force Devoted to the Production of Defense Goods in the United States and the Soviet Union, GE-TEMPO draft report, GE 76 TMP-54B, October 1977.

to the capital, as well as to the labor, resource. In addition, a new surrogate methodology is presented in Appendix B for the purpose of implementing the fourth approach to the estimation of the Soviet defense burden. Inasmuch as the Soviet civilian labor force can be distributed by skill category as well as by sector of employment, then sectoral burden ratios may be calculated for each skill category. In the same way, the Soviet stock of fixed and working capital may be distributed by durability category as well as by sector of employment. Therefore, sectoral burden ratios may also be calculated for buildings and structures, machinery and equipment, and total inventories as distinct durability categories of the Soviet capital stock. Moreover, the resource allocation incidence pattern during time period 1966-1971 for each sectoral burden ratio may also be determined.

The series of experiments described in Appendices A and B are concerned with the historical time period associated with the baseline methodology estimates in Table 2.22; i.e., 1960-1975 in Appendix A and 1966-1971 in Appendix B. By contrast, the ex ante resource allocation analysis of the estimated level of Soviet NSE described in Appendix C is concerned with the projected time period 1976-1985. This requires the use of an econometric model to provide an abstraction of the basic components of the Soviet economy. Fortunately, a relatively simple model for this purpose has been recently developed by Hans Bergendorff and Per Strangert. This model consists of the following four branches:

- Industry,
- Agriculture,
- Construction, and
- Transport and Communication,

with the Gross National Product distributed among the Consumption, Investment, and Defense spending categories.[175] The model calculates Defense spending on the basis of an exogenously determined growth rate, while the Consumption and Investment categories are calculated on the basis of the following three alternative experimental conditions:

- Consumption is exogenous, but Investment is endogenously determined as a residual;

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[175] H. Bergendorff and P. Strangert, "Projections of Soviet Economic Growth and Defense Spending," Soviet Economy in a New Perspective, Joint Economic Committee report, October 14, 1976, pages 394-430.

- Investment is exogenous, but Consumption is endogenously determined as a residual; and
- Both Consumption and Investment are endogenously determined with their shares of non-defense gross national product provided exogenously.

For each of these experimental conditions, the following resource allocation experiments were conducted for the purpose of examining the impacts of a given rate of growth of Soviet NSE:

- The Cobb-Douglas production function with an elasticity of substitution of unity is initially estimated for each of the four branches of the model previously identified. The industrial branch is then re-estimated with a Constant Elasticity of Substitution (CES) production function with an elasticity of substitution of one-half.
- New technology is introduced into the industrial production function on the basis of domestic research and development or foreign technology transfer. This productivity effect (i.e., Hicks neutral technological change) has resource allocation implications for a given rate of growth in Soviet defense expenditures.
- The share of Soviet GNP that is devoted to defense spending is changed, and the resource allocation impacts are then examined.
- The sectoral composition of Soviet defense spending between the industrial and construction sectors is changed in order to examine the impacts upon resource allocation when the given growth rate of Soviet NSE changes.

Utilizing the three sets of alternative experimental conditions previously identified, H. Bergendorff and P. Strangert have performed the foregoing three resource allocation experiments which actually constitute nine experiments (i.e., three sets of experimental conditions and three resource allocation experiments). These experiments are reviewed and illustrated in detail in Appendix C.[176]

Although the technology transfer issue and the production function specification problem may be illustrated by means of the simple Bergendorff-Strangert

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[176] Since the rate of growth of Soviet NSE for the projected time period 1976-1985 is an exogenous parameter in the Bergendorff-Strangert model, then each of the baseline methodology estimates in Table 2.22 may be evaluated in terms of its available rate of growth for the historical period 1960-1975. However, the rates of growth for the epoch periods 1960-1969 and 1970-1975 in Table 2.22 are used in Appendix C to define a trade-off range for the growth rates of Soviet NSE in the projection period 1976-1985.

model, the more sophisticated Soviet Econometric Model (SOVMOD III) developed by the Stanford Research Institute and the Wharton Econometric Forecasting Associates[177] (SRI-WEFA) is really more appropriate. By way of comparison with the Bergendorff-Strangert model, the SRI-WEFA model consists of the following six branches:

- Aggregate Industry,
- Agriculture,
- Construction,
- Transport and Communication,
- Domestic Trade, and
- Government and Services.[178]

Of these, the Aggregate Industry branch is further disaggregated into the following twelve sectors:

- Electroenergy,
- Coal Products,
- Petroleum Products,
- Ferrous Metallurgy,
- Nonferrous Metallurgy,
- Chemicals and Petrochemicals,
- Machine-Building and Metalworking,
- Forest Products,
- Paper and Pulp,
- Construction Materials,
- Soft Goods, and
- Processed Foods.

Similar to the Bergendorff-Strangert model, SOVMOD III distributes the Soviet Gross National Product into various end-use categories (i.e., Consumption, Investment, Defense, and Nondefense Governmental spending). However, as

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[177] D. Green and H. Levine, The SRI-WEFA Soviet Econometric Model: Phase Three Documentation, Volume II, Stanford Research Institute, Technical Note SSC-TN-2970-6, October 1976.

[178] Op. Cit., D. Green and H. Levine, The SRI-WEFA Soviet Econometric Model: Phase Three Documentation, Volume I, Technical Note SSC-TN-2970-5, May 1977, page 2.

discussed in detail in Appendix C, the SRI-WEFA model provides a much richer combination of alternative experimental conditions than the three previously described for the Bergendorff-Strangert model.[179] As a matter of fact, SOVMOD III has been utilized by Donald Green and Herbert Levine to conduct more sophisticated analyses, such as that of the technology transfer issue.[180] The results of this analysis are summarized as follows:

> In an attempt to quantify the gains from technology transfer, there are clear advantages to focussing on imported machinery and equipment. Machines imported from nations more technologically advanced can shift a domestic production function upward in three different ways:
>
> (1) directly through higher productivity in domestic production;
>
> (2) indirectly through use in the production of more efficient domestic machinery; and
>
> (3) even more indirectly through the transmission of information which results in a higher domestic level of technology.
>
> In order to estimate the contribution of imported machinery to Soviet industrial production, we first construct a measure of foreign capital from Soviet import data, and use that measure to disaggregate the capital stock into foreign and domestic categories. Production functions are then estimated with three factors of production: labor, foreign capital, and domestic capital. We assume that each imported machine carries potential information which may raise the level of Soviet technology. Given a constant expenditure of internalization effort (analysis and diffusion) per unit of imported machinery, the level of domestic technique will depend upon current and past levels of machinery imports. When one estimates the "contribution" to output of the marginal foreign machine, there are two components to the marginal productivity:
>
> - one, a direct measure of productivity, and
> - two, its contribution to the productivity of domestically produced machinery.
>
> If this "learning" component is significant then we ought to find the marginal productivity of foreign capital estimated in a production function to be higher than what one might judge reasonable for direct productivity relative to domestic capital, and that is exactly what our preliminary econometric results suggest. However, these data do not take into account additional costs to the use of foreign machinery.

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179 *Ibid., Volume II*, pages 3-4, which describes eight alternative switch conditions--each of which consists of an alternative experimental condition. Switch conditions 2, 4, and 5 correspond to the experimental conditions associated with the Bergendorff-Strangert model.

180 D.W. Green and H.S. Levine, "Macroeconometric Evidence of the Value of Machinery Imports to the Soviet Union," reproduced in Soviet Science and Technology: Domestic and Foreign Perspectives, edited by J.R. Thomas and U.M. Kruse-Vaucienne, George Washington University, Washington, D.C., 1977, pages 394-412.

There appears to be an apparent contradiction between the qualitative impression of Soviet difficulties with the absorption of advanced technology at the microeconomic level and the quantitative estimates of the impact of imported Western machinery at the macroeconomic level, derived from the SRI-WEFA Soviet econometric model. The results appear to show a greater payoff to the importation of foreign technology than might have been assumed from the qualitative-analytical and anecdotal literature (both Western and Soviet) on the Soviet economy.[181]

The "apparent contradiction" between the microeconomic evidence pertaining to Soviet assimilation of Western technology and the macroeconomic evidence provided by SOVMOD III is attributed to "omitted costs," which are explained as follows by Donald Green and Herbert Levine:

> The magnitude of the impact of imported machinery on industrial output depends on the calculation of the domestic value of the foreign machinery stock and the specification of the production function...The Cobb-Douglas specification was retained but is now estimated in growth rates rather than in log-linear form...[182]
>
> However, the process of technology transfer involves additional expenditures of domestic resources (particularly skilled manpower) as well as supplementary payments for technical assistance from abroad. Unfortunately, these expenditures at the aggregate level, at least those involving domestic resources, cannot be observed.[183]

Although it may not be possible to completely resolve this "apparent contradiction" until a surrogate methodology is developed to estimate the "omitted costs," it is possible to examine the specification of the production functions which are used. Inasmuch as the sectoral production functions assumed a unitary elasticity of substitution (i.e., a Cobb-Douglas specification), only the following sectors are involved in the technology transfer experiment:

- Petroleum Products,
- Chemicals and Petrochemicals, and
- Machine-Building and Metal-Working.

It should be noted that foreign and domestic categories of stock are introduced separately as factors of production. Recent econometric evidence suggests that the elasticity of substitution is about one-half (½) for the Petroleum Products sector and about one-fourth (¼)

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[181] Ibid., pages 31-32 and 37 (underlining added for highlighting purposes).

[182] Ibid., pages 395 and 398 (underlining added for highlighting purposes).

[183] Op. Cit., D. Green and H. Levine, The SRI-WEFA Soviet Econometric Model: Phase Three Documentation, Volume I, page 37.

for the Chemicals and Petrochemicals sector.[184] Only the Machine-Building and Metal-Working sector has an estimated elasticity of substitution close to unity which justifies the use of the Cobb-Douglas specification. However, the Constant Elasticity of Substitution (CES) production function would be more appropriate for the Petroleum Products, as well as the Chemicals and Petrochemicals, sectors.[185] Therefore, an expansion of the CES production function specification to provide a short-run "variable elasticity of substitution" form, which reduces to the CES specification in the long-run, is presented in detail in Appendix C.[186]

This generalization of the Cobb-Douglas production function may be summarized in terms of the alternative experimental conditions to be imposed, to include a general case and three special cases--the latter of which reflect setting the capital-labor adjustment parameter to zero, setting the competitive wage adjustment parameter to unity, or setting both to zero and unity, respectively.[187] These four cases are briefly described as follows:

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184 Steven Rosefielde, East-West Trade and Postwar Soviet Economic Growth: A Sectoral Production Function Approach, October 1, 1976, Table A4.1-1, page 108. In this analysis, Fuels (σ = .5323), Chemicals (σ = .2831), and Machinery and Equipment (σ = .9998) are reasonably close to the corresponding SRI-WEFA sectoral definitions.

185 The basis for the Cobb-Douglas specification is explained by D.W. Green in "The Microfoundations of Soviet Production Functions: An Engineering Approach," SRI Working Paper No. 45, April 1976. Data for the Machine-Building and Metal-Working sector, which is a very special case, was used to evaluate the Cobb-Douglas versus the CES specification. Other methodological criticisms of this working paper are presented in Appendix C.

186 Karl W. Roskamp, "A Generalized Production Function for West German Industries," Weltwirtschaftliches Archiv, Band 112, Heft 4, 1976, pages 749-753.

187 In order to use these alternative production functions in the SRI-WEFA SOVMOD III specifications, a linearized form using Taylor's formula and disregarding terms of third and higher orders is required. However, this linearization for the CES specification has already been performed by J. Kmenta in "On Estimation of the CES Production Function," International Economic Review, Volume 8, No. 2, June 1967, pages 180-189. The linearization for the three special cases is presented and related to the engineering approach originally adopted by SRI-WEFA in SOVMOD III in Appendix C of this report.

- The conventional CES production function, which presumes that the wages paid to Soviet workers reflect the marginal productivity of labor principle and that the capital-labor ratio has completely adjusted to correspond with the wage rate for each time period. In the general case, there is a competitive wage rate adjustment parameter, as well as a capital-labor adjustment parameter, which must be set to unity and zero, respectively, in order to produce the conventional CES production function. By permitting these two adjustment parameters to assume other values, a two-fold family of first-degree homogeneous production functions will result.

- The "Bruno production function," which results when the capital-labor ratio adjustment parameter is not equal to zero, but the wages paid to Soviet workers are still assumed to reflect the marginal productivity of labor principle. In other words, the competitive wage rate adjustment parameter is still set equal to unity.[188] This case takes into consideration the existing sociological, organizational, and technological rigidities which are characteristic of the Soviet production process. In the long-run, the Soviet capital-labor ratio for each sector may adjust to its neoclassical production theory value and, in this context, the

  - Capital-labor ratio adjustment parameter will converge to unity, and

  - "Short-run Bruno production function" with a variable elasticity of substitution will converge with the "long-run" CES production function with a constant elasticity of substitution.

  Of course, if this constant value is unity, then the Cobb-Douglas production function becomes an additional special case--which is the specification currently being applied by SRI-WEFA in the SOVMOD III production function.

- The case wherein the capital-labor ratio adjustment parameter is equal to zero, but the competitive wage rate adjustment parameter is not equal to unity, which takes into consideration the distortions in remuneration to labor caused by the intervention of Soviet authorities. In a market economy, such distortions would reflect monopoly and monopsony power but, in the Soviet production process, it reflects the exercise of political power. Although it is assumed that the capital-labor ratio will adjust in line with the non-competitive wage rate, this is not generally a realistic assumption.

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[188] The "Bruno production function," which is highlighted in Appendix C and is often referred to as a Variable Elasticity of Substitution (VES) production function, is described in a somewhat different form by Marc Nerlove in his article on "Recent Empirical Studies of the CES and Related Production Functions," in The Theory and Empirical Analysis of Production, edited by Murray Brown, National Bureau of Economic Research Studies in Income and Wealth, Volume 31, New York, 1967, pages 75-77. The Technical derivation of this function is provided by Yao-chi Lu and Lenman B. Fletcher in "A Generalization of the CES Production Function," The Review of Economics and Statistics, Volume 50, Number 4, November 1968, pages 449-452.

- The case wherein the capital-labor ratio adjustment parameter is not equal to zero, and the competitive wage rate adjustment parameter is not equal to unity, which reflects a general situation that takes into consideration both the rigidities of the Soviet production process and the exercise of political power to manipulate the wages paid to the labor force.

The foregoing cases define the basic experimental conditions wherein the Green/Levine technology transfer experiment may be reiterated. A more general specification of the demand equations for Soviet imports of machinery are provided in Appendix C.

3.5 AN EX POST RESOURCE ALLOCATION ANALYSIS OF THE ESTIMATED LEVEL OF SOVIET NATIONAL SECURITY EXPENDITURES

The remainder of Section 3.0 is devoted to a discussion of the various resource allocation experiments described in Appendices A, B, C, and D of Volume II. These experiments examine the resource allocation implications of the various estimates of Soviet defense expenditures presented in Table 2.22. Appendices A and B are concerned with an ex post resource allocation analysis of the alternative baseline estimates by examining the decomposition of Soviet Gross National Product (GNP) by end-use categories and by sector of origin, respectively, for the historical period 1960-1975. Inasmuch as the decomposition of GNP by end-use categories (e.g., Consumption, Investment, Defense, and non-defense Government Spending) requires only an estimation of the magnitude of Soviet NSE, it is therefore possible to examine the quality of all the baseline methodologies as described in Appendix A--given alternative hypotheses with regard to "undetected" versus "hidden" levels of Soviet defense spending in the Soviet GNP accounts.

3.5.1 Resource Allocation Experiments

Twenty resource allocation experiments are defined in Table A-8 of Appendix A. These experiments reflect alternative assumptions with regard to the magnitude of undetected Soviet NSE that must be added to the National Income Accounts "residual" in each time period. A certain percentage of this undetected Soviet defense spending may be added directly to GNP with the

remaining percentage hidden among the Consumption, Investment, and Administrative Governmental expenditure categories. These conditions may be observed by expressing the end-use distribution of Soviet GNP for each time period in the original National Income Accounts as follows:

$$GNP_t = C_t + I_t + A_t + D_t . \tag{48}$$

The same type of end-use distribution associated with the ith baseline methodology in Table 2.22 may then be expressed as follows:

$$GNP_{it} = C_{it} + I_{it} + A_{it} + D_{it} . \tag{49}$$

As may be observed, Equations (48) and (49) correspond to Equations (A-1) and (A-10), respectively, in Appendix A, and the relationships between each term in Equations (48) and (49) may be summarized as follows:

$$GNP_{it} = GNP_t + (1 - \lambda_{iC} - \lambda_{iI} - \lambda_{iA})\omega_{it}, \tag{50}$$

$$C_{it} = C_t - \lambda_{iC}\omega_{it}, \tag{51}$$

$$I_{it} = I_t - \lambda_{iI}\omega_{it}, \tag{52}$$

$$A_{it} = A_t - \lambda_{iA}\omega_{it}, \text{ and} \tag{53}$$

$$D_{it} = D_t + \omega_{it}. \tag{54}$$

In this context,

- D_t represents the original National Income Accounts "residual" associated with Soviet defense spending,
- ω_{it} represents the magnitude of undetected Soviet defense spending associated with D_{it} in Equation (54),[189] and
- The percentage of ω_{it} that may be added to GNP_t in Equation (50) is represented by $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})$, where λ_{iC}, λ_{iI}, and λ_{iA} are the percentages of ω_{it} hidden among the C_t, I_t, and A_t categories as reflected in Equations (51), (52), and (53), respectively.

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[189] Inasmuch as ω_{it} may be either positive or negative, then it is actually a measurement error term which may be used to resolve the discrepancy between D_{it} (i.e., the estimated level of Soviet defense spending associated with the ith baseline methodology) and D_t (i.e., the residual amount of GNP_t available to cover Soviet defense spending) in Equation (54). In Table A-8, the $\hat{\omega}_{1970}$ terms are all nonnegative, which reflects alternative hypotheses with respect to undetected Soviet defense spending in 1970, and are incorporated in the testing methodology.

By substituting Equations (51)-(54) into Equation (49), GNP_{it} may be restated as follows:

$$GNP_{it} = (C_t + I_t + A_t) + D_t + (1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it} \quad (55)$$

where $(C_t + I_t + A_t)$ is the original "non-defense" share of GNP_t in Equation (48), D_t is the original "defense" share of GNP_t, and $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}$ is that percentage of the "undetected" Soviet defense spending that is not "hidden" among the other end-use categories and must be added to the original estimate of GNP_t.

Since the magnitude of $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}$ reflects the relative importance of both polar case explanations for the discrepancy between D_{it} and D_t in Equation (54) (i.e., some Soviet defense spending is "undetected" or is "hidden" in other end-use categories), then the fundamental principle upon which the ex post resource allocation experiments in Appendix A are based may be illustrated in Figure 3.0. However, this requires that Equation (55) be converted to a unit sum as follows:

$$1 = \frac{(C_t + I_t + A_t)}{GNP_{it}} + \frac{D_t}{GNP_{it}} + \frac{(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}}{GNP_{it}} \quad (56)$$

with each ratio of this sum plotted as shown on the unit simplex of Figure 3.0; i.e., the (D_t/GNP_{it}) ratio is represented by the line aa and the $(C_t + I_t + A_t)/GNP_{it}$ ratio is represented by the line bb--the intersection of which determines point A.[190]

This representation corresponds to the original National Income Accounts estimate of Soviet GNP_t with line aa as the non-defense share of GNP_t and line bb as the defense share. In Appendix A, the estimated end-use distribution of Soviet GNP_t is based upon sample indexes developed by the CIA Office of Economic Research (OER).[191]

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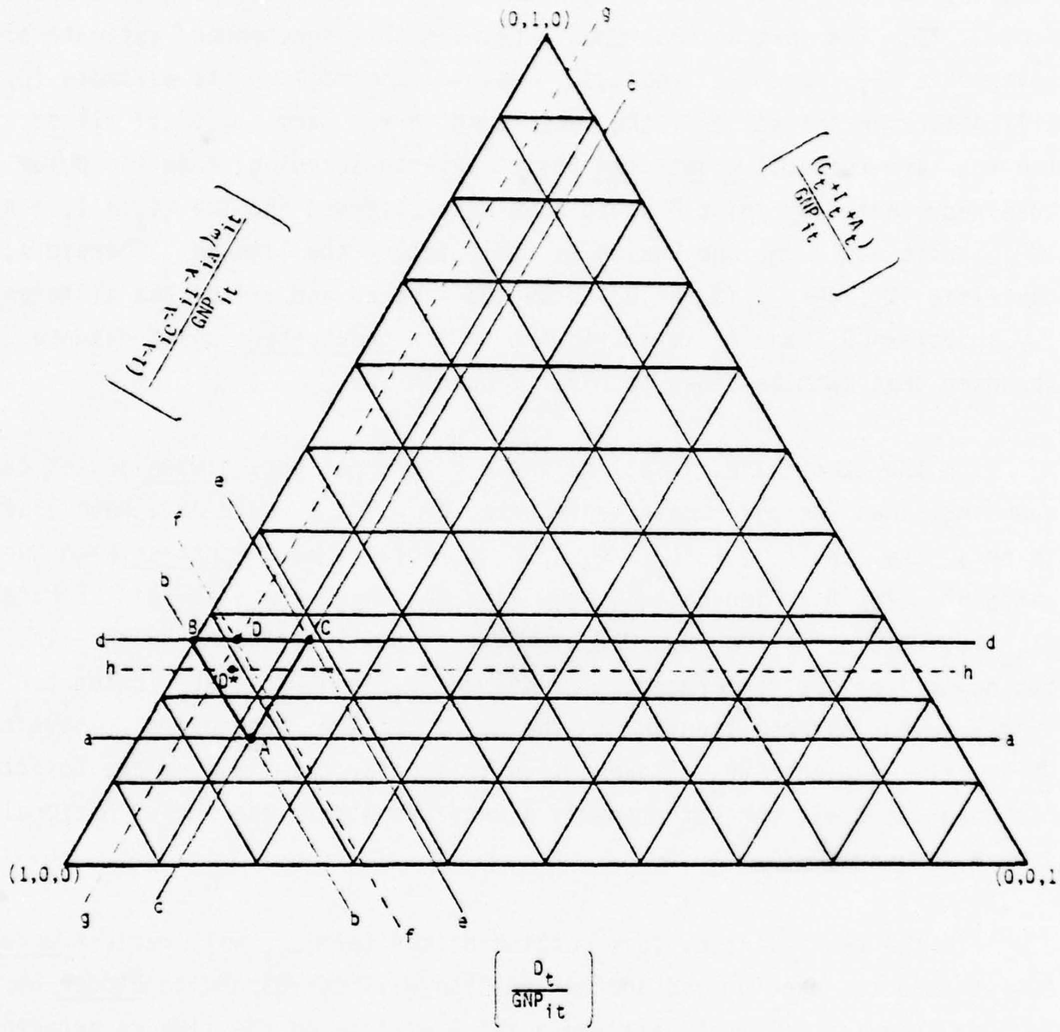
190 The value of ω_{it} is assumed to be positive so that point A is within the unit simplex of Figure 3.0--which reflects the discrepancy of interest between D_{it} and D_t.

191 Rush Greenslade, "The Real Gross National Product of the USSR, 1950-1975," JEC report, Soviet Economy in a New Perspective, October 14, 1976, Table 5, page 275. An alternative estimate of the end-use distribution of Soviet GNP_t based on Soviet statistical handbooks and other official sources has been developed by William T. Lee in his unpublished working paper entitled "USSR GNP in Established Prices, 1955-1975".

Figure 3.0 An Illustration of the Fundamental Principle Associated with the Ex Post Resource Allocation Experiments in Appendix A



- Point A represents the original $GNP_t = C_t+I_t+A_t+D_t$ (Equation 48).
- Point B represents the estimated $GNP_{it} = C_{it}+I_{it}+A_{it}+D_{it}$ (Equation 49), when all of ω_{it} is hidden; i.e., $(\lambda_{iC}+\lambda_{iI}+\lambda_{iA}) = 1$, which is a polar case.
- Point C represents the estimated $GNP_{it} = C_{it}+I_{it}+A_{it}+D_{it}$ (Equation 49), when all of ω_{it} is undetected; i.e., $(\lambda_{iC}+\lambda_{iI}+\lambda_{iA}) = 0$, which is also a polar case.
- Point D represents an estimated $GNP_{it} = C_{it}+I_{it}+A_{it}+D_{it}$ associated with Table 2.22.
- Point D* represents one of the experimental conditions in Table A-8 of Appendix A, given values for $\lambda_{iC},\lambda_{iI},\lambda_{iA}$ and ω_{it}.

Point D in Figure 3.0 represents an independent estimate of the level of Soviet NSE by means of one of the baseline methodologies shown in Table 2.22. The initial discrepancy between this independent estimate of Soviet NSE (D_{it}) and the "residual" National Income Accounts estimate (D_t) will determine the value of the measurement error term, ω_{it}. If all of the a_{it} term reflects undetected Soviet defense spending, then the polar case represented by point B would have been observed and the $(C_t + I_t + A_t)/GNP_{it}$ ratio would decline, which is reflected by the line ee. Therefore, the ratio (D_{it}/GNP_{it}) is reflected by the line dd and all of the difference (ω_{it}) between D_{it} and D_t is attributed to the undetected Soviet defense spending that must be added to GNP_t to obtain GNP_{it}.

On the other hand, if all of the a_{it} term reflects hidden Soviet defense spending, then the polar case represented by point B would have been observed. In this case, the $(C_{it} + I_{it} + A_{it})/GNP_{it}$ ratio remains constant with the ratio at point A as indicated by the line bb, which contains point B because $(\lambda_{iC}+\lambda_{iI}+\lambda_{iA}) = 1$. The (D_{it}/GNP_{it}) ratio is still reflected by the line dd, but now all of the difference (ω_{it}) between D_{it} and D_t is attributed to hidden Soviet defense spending in the C_t, I_t, and A_t categories. Therefore, GNP_{it} still exceeds GNP_t. However, in this polar case, all of the Soviet NSE has been detected, but not properly identified within the Soviet National Income Accounts.

In the general case, some portion of the term ω_{it} will reflect undetected Soviet defense spending and another portion will correspond to hidden Soviet defense spending, so that observed point D will be on the line dd between the polar case represented by point C and the polar case represented by point B as reflected in Figure 3.0. External estimates of the λ_{iC}, λ_{iI}, and λ_{iA} parameters for the percentage of ω_{it} hidden in the C_t, I_t, and A_t categories to implement Equations (51), (52), and (53) determine the lines ff and gg in Figure 3.0.[192]

[192] The line ff is determined by the $[C_t + I_t + A_t - (\lambda_{iC}+\lambda_{iI}+\lambda_{iA})\omega_{it}]/GNP_{it}$ ratio, where the polar case (line ee) is determined by the $(C_t + I_t + A_t - \omega_{it})/GNP_{it}$ ratio and line gg is determined by the $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}/GNP_{it}$ ratio. External estimates of the λ_{iC}, λ_{iI}, and λ_{iA} parameters used in Appendix A are based upon John Pitzer's "Reconciliation of Gross National Product and Soviet National Income," CIA OER, December 1977, Table 6, page 25.

The resource allocation experiments which are summarized in Table A-8 of Appendix A are based upon Equation A-18, also in Appendix A, and involve the disaggregation of the ratio $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}/GNP_{it}$ into a systematic component and a random component as follows:

$$\left[\frac{(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}}{GNP_{it}}\right] = \left[\frac{\hat{\omega}_{1970}(1+r_*)^{t-1970}}{GNP_{it}}\right] + \left[\frac{\omega^*_{it}}{GNP_{it}}\right] \quad (57)$$

In principle, if the observed estimate of D_{it} and the original value of GNP_t are compatible, then any significant difference may be explained by means of the assumptions used to estimate the systematic component in Equation (57). The observed estimate of D_{it} in Figure 3.0 corresponds to point D, while the original value of GNP_t corresponds to point A. Alternative experimental values for $\hat{\omega}_{1970}$ are presented in Table A-8 of Appendix A. In addition, alternative experimental assumptions with regard to the percentage of total research and development expenditures allocated for Soviet defense determine the values of other parameters which are required to implement Equation (A-19) as described in Appendix A. Based upon these assumptions for one of the 20 experiments in Table A-8, the "predicted" value for the estimate of D_{it} is determined as indicated by point D* on the line hh in Figure 3.0. The systematic component of Equation (57) [i.e., $\hat{\omega}_{1970}(1+r_*)^{t-1970}/GNP_{it}$] reflects how much the line gg must shift in order to define point D*. Moreover, estimation of the random component of Equation (57) (i.e., ω^*_{it}/GNP_{it}) based upon Equation (A-23) in Appendix A will define the line hh, which reflects how much the line dd must shift in order to define point D*.

Obviously, if the experimental assumptions are <u>completely appropriate</u> with respect to explaining the original measurement error (ω_{it}), then point D* will coincide with point D in Figure 3.0--in which case, <u>all</u> of the estimated value of the "observed" D_{it} will have been "predicted" by the experimental assumptions, so that the ratio ω^*_{it}/GNP_{it} will be zero in Equation (57). On the other hand, if the experimental assumptions are <u>completely inappropriate</u>, then point D* will coincide with point A in Figure 3.0--in which case <u>none</u> of the estimated value of the "observed" D_{it} will have been "predicted" by the experimental assumptions, so that the ratio ω^*_{it}/GNP_{it} will

equal $(1-\lambda_{iC}-\lambda_{iI}-\lambda_{iA})\omega_{it}/GNP_{it}$ in Equation (57). Generally speaking, the experimental assumptions are only partially appropriate, so that point D* will not coincide with point D or with point A in Figure 3.0. Therefore, a "goodness of fit" test based upon the F-statistic has been developed in Equation (A-24) of Appendix A in order to determine if point D* and point D are significantly close in a statistical sense. The null hypothesis is formulated on the basis of the random component of Equation (57) and, if accepted, then D_{it} and GNP_t are "not demonstrably inconsistent"--given the experimental assumptions. This means that the remaining measurement error, which will cause line dd to shift to line hh, is negligible because it is not statistically significant.

3.5.2 An Analysis of the Results of the Resource Allocation Experiments

The results of the 20 resource allocation experiments described in Appendix A are summarized in Table 3.1 for each of the baseline estimation techniques. As may be observed, the results are expressed in terms of estimates of $\beta_{i,1970}$; i.e., the percentage of Soviet Outlays n.e.c. (not otherwise classified) for defense expenditures in the year 1970 with baseline estimation technique i. However, each cell of Table 3.1 contains not only an estimate of $\beta_{i,1970}$, but also a reflection of the comparison of each estimate with the acceptable range of $\beta_{i,1970}$ defined in Equation (A-22) of Appendix A; i.e., $.67 \leq \hat{\beta}_{i,1970} \leq .90$. In this context, an estimate may be identified as "unacceptable" because it is either (low) or (high). An estimate may also be identified as "unacceptable" if the value of the F-statistic defined in Equation (A-24) of Appendix A exceeds 4.60 at the 5% level, which is indicated by an asterisk [*], or 8.86 at the 1% level, which is indicated by two asterisks [**]. The number of "acceptable" baseline estimates is reflected in the bottom row of Table 3.1 which indicates that:

- The Official Soviet Defense Budget (i.e., Column 1), IISS Original Budgetary Technique (i.e., Column 2), and French National Expenditure method (i.e., Column 3) are "unacceptable" because they are incompatible with Rush Greenslade's National Income Accounts for GNP in all of the 20 experiments.

Table 3.1 Results of the Ex Post Resource Allocation Experiments for each of the Soviet NSE Baseline Estimation Techniques [193]

Techniques / Experiments	Official Soviet Defense Budget	Original Budgetary Technique (IISS Estimates)	FNE and SE Residuals Technique (SIPRI Estimates)	Revised Budgetary Technique (Stanley Cohn's Estimates): State Reserves Basis	Revised Budgetary Technique (Stanley Cohn's Estimates): Final Demand Basis	Production Residual Estimation Technique (Bill Lee's Estimates): Establishment Basis	Production Residual Estimation Technique (Bill Lee's Estimates): Commodity Basis	National Expenditure Method (French Estimates)	Direct Costing Technique (CIA Estimates)	External Information Method (Chinese Estimates)
Experiment No. 1 Cohn a_{it} Pitzer a_{1970} = 0.	.333 (low)	.548 (low)	.891	.816	.786	1.109 (high)	.949 (high)	.775 [*]	1.012 (high) [*]	1.1836 (high)
Experiment No. 2 Cohn a_{it} Greenslade a_{1970}=5.5	.181 (low)	.396 (low)	.739	.564 (low)	.534 (low)	.957 (high)	.797	.623 (low) [*]	.860 [*]	1.032 (high)
Experiment No. 3 Cohn a_{it} Mixture a_{1970}=8.6	.095 (low)	.311 (low)	.653 (low)	.578 (low)	.548 (low)	.871	.711	.537 (low) [*]	.775 [*]	.946 (high)
Experiment No. 4 Cohn a_{it} Lee a_{1970}=11.7	.009 (low)	.225 (low)	.568 (low)	.493 (low)	.463 (low)	.786	.626 (low)	.451 (low) [*]	.689 [*]	.860
Experiment No. 5 Cohn a_{it} Diamond a_{1970}=25.	-.358 (low)	-.142 (low)	.200 (low)	.125 (low)	.095 (low)	.418 (low)	.258 (low) [*]	.084 (low)	.322 (low)	.493 (low)
Experiment No. 6 Mixture a_{it} Pitzer a_{1970}=0.	.309 (low)	.525 (low)	.868	.793	.763	1.086 (high)	.926 (high)	.751 [*]	.989 (high) [*]	1.160 (high)
Experiment No. 7 Mixture a_{it} Greenslade a_{1970}=5.5	.157 (low)	.372 (low)	.715	.641 (low)	.611 (low)	.934 (high)	.774	.599 (low) [*]	.837 [*]	1.008 (high)
Experiment No. 8 Mixture a_{it} Mixture a_{1970}=8.6	.072 (low)	.287 (low)	.630 (low)	.555 (low)	.525 (low)	.848	.688	.514 (low) [*]	.751 [*]	.923 (high)
Experiment No. 9 Mixture a_{it} Lee a_{1970}=11.7	-.014 (low)	.202 (low)	.544 (low)	.470 (low)	.439 (low)	.763	.602 (low)	.428 (low) [*]	.666 [*]	.837
Experiment No. 10 Mixture a_{it} Diamond a_{1970}=25.	-.381 (low)	-.166 (low)	.177 (low) [*]	.102 (low)	.072 (low)	.395 (low)	.235 (low) [*]	.061 (low)	.298 (low) [*]	.470 (low)
Experiment No. 11 Lee a_{it} Pitzer a_{1970}=0.	.236 (low)	.502 (low)	.844	.770	.739	1.062 (high)	.902 (high)	.728 [*]	.966 (high) [*]	1.137 (high)
Experiment No. 12 Lee a_{it} Greenslade a_{1970}=5.5	.134 (low)	.350 (low)	.692	.618 (low)	.587 (low)	.911 (high)	.750	.576 (low) [*]	.814 [*]	.985 (high)
Experiment No. 13 Lee a_{it} Mixture a_{1970}=8.6	.048 (low)	.264 (low)	.607 (low)	.532 (low)	.502 (low)	.825	.665 (low)	.491 (low) [*]	.728 [*]	.899
Experiment No. 14 Lee a_{it} Lee a_{1970}=11.7	-.037 (low)	.178 (low)	.521 (low)	.446 (low)	.416 (low)	.739	.579 (low) [*]	.405 (low) [*]	.642 (low) [*]	.814
Experiment No. 15 Lee a_{it} Diamond a_{1970}=25.	-.405 (low)	-.189 (low)	.153 (low) [*]	.079 (low)	.048 (low)	.372 (low)	.211 (low) [*]	.037 (low)	.275 (low) [*]	.446 (low)
Experiment No. 16 CIA a_{it} Pitzer a_{1970}=0.	.201 (low)	.496 (low)	.839	.764	.734	1.057 (high)	.897	.723 [*]	.960 (high) [*]	1.132 (high)
Experiment No. 17 CIA a_{it} Greenslade a_{1970}=5.5	.129 (low)	.344 (low)	.687 (low)	.612 (low)	.582 (low)	.905 (high)	.745	.571 (low) [*]	.808	.980 (high)
Experiment No. 18 CIA a_{it} Mixture a_{1970}=8.6	.043 (low)	.258 (low)	.601 (low)	.525 (low)	.496 (low)	.819	.659 (low)	.485 (low)	.723	.894
Experiment No. 19 CIA a_{it} Lee a_{1970}=11.7	-.043 (low)	.173 (low)	.515 (low)	.441 (low)	.410 (low)	.734	.573 (low) [*]	.399 (low)	.637 (low)	.808
Experiment No. 20 CIA a_{it} Diamond a_{1970}=25.	-.410 (low)	-.195 (low) [*]	.148 (low) [*]	.073 (low)	.043 (low)	.366 (low)	.206 (low) [*]	.032 (low)	.269 (low)	.441 (low)
The Total Number of Acceptable $a_{i,1970}$ Estimates	0	0	7	4	4	5	7	0	2	5

[193] This table summarizes the results of the twenty resource allocation experiments performed in Appendix A in terms of estimates of $a_{i,1970}$; i.e., the percentage of Soviet Outlays n.e.c. (not elsewhere classified) for defense expenditures in the year 1970 with baseline estimation technique i. Each cell of this table contains not only an estimate of $a_{i,1970}$, but also a reflection of the comparison of each estimate (e.g., low or high) with the acceptable range of $a_{i,1970}$ defined in Equation (A-22) of Appendix A; i.e., $.67 \leq a_{i,1970} \leq .90$. Moreover, when the value of the F-statistic defined in Equation (A-24) of Appendix A exceeds 4.60 at the 5% level, it is identified by means of an asterisk [*]. Similarly, when the value of the F-statistic exceeds 8.86 at the 1% level, it is identified by means of two asterisks [**]. From the standpoint of the given experimental conditions and the criteria defined in Equations (A-22) and (A-24), an "acceptable" baseline estimate (and associated technique) is identified by means of an estimate of $a_{i,1970}$ without a (low), (high), [*], or [**]. The number of such "acceptable" estimates is reflected in the bottom row of Table 3.1.

- The CIA direct costing technique is only compatible with Rush Greenslade's Soviet GNP data for 2 of the 20 experiments; i.e., Experiments Nos. 17 and 18 wherein the CIA estimates of $\hat{\alpha}_{it}$ (percentage of total Soviet R&D expenditures for defense in time period t with estimation technique i) and Rush Greenslade's estimate of $\hat{\omega}_{1970}$ = 5.5 billion rubles, or a slightly greater value ($\hat{\omega}_{1970}$ = 8.6), are used. In this context, Rush Greenslade's first hypothesis in Appendix A (i.e., "the Soviet GNP is too low in 1970 by about 5.5 billion rubles") is consistent with the CIA estimates from 1960 to 1975. This compatibility is achieved by assuming that 14 percent of Soviet NSE is "hidden" in Consumption, Investment, and Non-Defense Government spending as reflected in Equation (A-25) of Appendix A--which means that Rush Greenslade's third hypothesis was replaced with John Pitzer's data in Table A-10 of Appendix A in order to empirically test Rush Greenslade's first hypothesis. With reference to Rush Greenslade's first hypothesis, which is reflected in Experiment No. 17 and Column 9 of Table 3.1, it may be observed that Bill Lee's commodity basis estimates of Soviet NSE (i.e., Column 7) are also compatible with the same experimental conditions. Moreover, if Bill Lee's estimates of the parameter $\hat{\alpha}_{it}$ are used in lieu of the CIA's estimate of this parameter and all other experimental conditions remain unchanged, then the result is Experiment No. 12. In this case, Bill Lee's commodity basis estimates in Column 7 are still compatible with the estimates of Soviet GNP, but now the CIA estimates in Column 9 are <u>incompatible</u> because the F-statistic is "unacceptable". Therefore, a comparison of Experiments Nos. 12 and 17 in terms of the estimating techniques identified in Columns 7 and 9 of Table 3.1 indicates that the estimate of $\hat{\beta}_{i,1970}$ associated with the CIA technique is only "acceptable" with the CIA estimates of the parameter $\hat{\alpha}_{it}$. By contrast, the estimate of $\hat{\beta}_{i,1970}$ associated with Bill Lee's commodity basis technique is "acceptable" with <u>both</u> the CIA's and Bill Lee's estimates of $\hat{\alpha}_{it}$. As a result, it may be observed that the CIA estimating technique is <u>less</u> "robust" than Bill Lee's commodity basis estimating technique because it is more sensitive to changes in the experimental conditions.

- Stanley Cohn's estimating technique in Columns 4 and 5 of Table 3.1 is "acceptable" in terms of the values of $\hat{\beta}_{i,1970}$ in only four of the twenty experimental conditions; i.e., experiments Nos. 1, 6, 11, and 16. As may be observed, the common factor among these four experiments is that John Pitzer's assumption that $\hat{\omega}_{1970}$ = 0 is maintained. It would therefore appear that Stanley Cohn's estimating technique is extremely sensitive to the assumption that the Soviet GNP in the year 1970 is correctly estimated (i.e., no "undetected" Soviet defense expenditures need to be added to the Soviet GNP). Any "missing" Soviet

defense expenditures must be "hidden" in other non-defense categories. In addition, it would appear that the compatibility of Stanley Cohn's estimating technique with Rush Greenslade's National Income Accounts for Soviet GNP is entirely insensitive to the choice of values for $\hat{\alpha}_{it}$ summarized in Table A-11 of Appendix A. Therefore, it may be observed that Stanely Cohn's estimating technique is also less "robust" than Bill Lee's estimating technique because it is extremely sensitive to John Pitzer's assumption that $\hat{\omega}_{1970} = 0$. In the same way, the CIA direct costing technique is extremely sensitive to the CIA assumption with regard to the value of $\hat{\alpha}_{it}$.

- Bill Lee's estimating technique in Columns 6 and 7 of Table 3.1 is "acceptable" in terms of the values of $\hat{\beta}_{i,1970}$ in more of the experimental conditions than any other technique. Inasmuch as none of the estimating techniques in Table 3.1 provide "acceptable" values of $\hat{\beta}_{i,1970}$ in Experiment Nos. 5, 10, 15, and 20 when the Douglas Diamond's assumption that $\hat{\omega}_{1970} = 25$ is used, then these experiments may be eliminated from further consideration at this time. Clearly, Douglas Diamond's estimate of undetected Soviet defense spending that must be added to Soviet GNP is "too high". For every other hypothesized value of $\hat{\omega}_{1970}$, it is possible to identify one of the four values of $\hat{\alpha}_{it}$ that will provide an "acceptable" value of $\hat{\beta}_{i,1970}$ in Columns 6 or 7. However, as would be generally anticipated, the low values of $\hat{\omega}_{1970}$ (i.e., 0.0 and 5.5) are more compatible with Bill Lee's commodity basis estimates in Column 7, whereas the middle values of $\hat{\omega}_{1970}$ values (i.e., 8.6 and 11.7) are more compatible with Bill Lee's establishment basis estimates in Column 6. It may therefore be observed that Bill Lee's estimating technique is the most "robust" of all of the estimating techniques.

- The Chinese estimates in Column 10 of Table 3.1 are not compatible with the low values of $\hat{\omega}_{1970}$ (i.e., 0.0 and 5.5) for all of the four values of $\hat{\alpha}_{it}$. This means that, in order for the Chinese External Information Method to be compatible with Rush Greenslade's Soviet GNP accounts, then the middle values of $\hat{\omega}_{1970}$ (i.e., 8.6 and 11.7) must be assumed to represent the levels of "undetected" Soviet defense spending which must be added to the Soviet GNP. By contrast, the SIPRI estimates in Column 3 of Table 3.1 are not compatible with the middle values of $\hat{\omega}_{1970}$ (i.e., 8.6 and 11.7) for all of the four values of $\hat{\alpha}_{it}$. This means that, in order for the FNE and BE Residuals Technique to be compatible with Rush Greenslade's Soviet GNP accounts, then the low values of $\hat{\omega}_{1970}$ (i.e., 0.0 and 5.5) must be assumed as the levels of "undetected" Soviet NSE which must

be added to the Soviet GNP. Therefore, the Chinese and the SIPRI estimates are both sensitive to a particular range of the values of $\hat{\omega}_{1970}$ that must be assumed in order to attain "acceptable" estimates of $\hat{\beta}_{i,1970}$, but they are <u>not</u> sensitive to the choice of values for $\hat{\alpha}_{it}$ summarized in Table A-11 of Appendix A.

- In summary, the general ranking of the baseline estimation techniques in terms of "acceptable" values of $\hat{\beta}_{i,1970}$ and of the relative "robustness" of the techniques with respect to changes in assumptions pertaining to the values of $\hat{\alpha}_{it}$ and $\hat{\omega}_{1970}$ is as follows:

  - <u>Very robust</u>--Bill Lee's estimation technique (i.e., both the establishment basis and commodity basis) is most compatible with Rush Greenslade's National Income Accounts GNP in the resource allocation experiments because it will accept all of the four assumed values of $\hat{\alpha}_{it}$, as well as the low and middle values of $\hat{\omega}_{1970}$.

  - <u>Moderately robust</u>--The SIPRI and Chinese estimation techniques are moderately compatible in that they will accept all of the four assumed values of $\hat{\alpha}_{it}$, but only the low <u>or</u> middle assumption (not both) with regard to $\hat{\omega}_{1970}$.

  - <u>Slightly robust</u>--Stanley Cohn's estimation technique (i.e., both the State Reserve Basis and the Final Demand Basis) is slightly compatible in that it will accept all of the four assumed value of $\hat{\alpha}_{it}$, but only one assumption with respect to $\hat{\omega}_{1970}$ (i.e., $\hat{\omega}_{1970} = 0$). The CIA estimation technique is also slightly compatible in that it will accept only one assumption with regard to $\hat{\alpha}_{it}$ (i.e., the CIA values for $\hat{\alpha}_{it}$), but two of the assumptions with respect to $\hat{\omega}_{1970}$ (i.e., 5.5 and 8.6).

  - <u>Unacceptable</u>-- The Official Soviet Defense Budget, the IISS original budgetary technique, and the French national expenditure method are not compatible in terms of the resource allocation experiments in that they do not accept any of the values of $\hat{\alpha}_{it}$ and $\hat{\omega}_{1970}$ summarized in Table A-11 of Appendix A. In this context, <u>negative</u> values of $\hat{\omega}_{1970}$ must be assumed before these estimation techniques will be compatible with Rush Greenslade's National Income Accounts GNP (i.e., 1970 Soviet GNP is "too high" rather than "too low").

The resource allocation experiments summarized in Table 3.1 stressed the "acceptability" of estimates of $\hat{\beta}_{i,1970}$ in order to assess the "robustness"

of each of the baseline estimation methodologies with respect to changes in the experimental assumptions. The general ranking of these baseline methodologies in terms of their relative "robustness" may be augmented by means of the following mean-square-error F-statistic developed from the error term $\hat{\omega}^*_{it}$ defined in Equation (A-23) of Appendix A:

$$F_{ij} = \sum_{t=1}^{t=n} (\hat{\omega}^*_{it}-\theta_i)^2 / \sum_{t=1}^{t=n} (\hat{\omega}^*_{jt}-\theta_j)^2 \tag{58}$$

where $\sum_{t=1}^{t=n} (\hat{\omega}^*_{kt}-\theta_k)^2 = n(\bar{\omega}^*_k-\theta_k)^2 + \sum_{t=1}^{t=n} (\hat{\omega}^*_{kt}-\bar{\omega}^*_k)^2$ for k =

i or j with i = 1,..., 9 and j = i+1,..., 10.

This test statistic is calculated for all of the resource allocation experiments in Table 3.1 with $\theta_i = \theta_j = 0$ substituted into Equation (58), which evaluates the null hypothesis

$$H_o: \sigma^{\alpha}_{\omega^*_i} = \sigma^{\alpha}_{\omega^*_j} \tag{59}$$

against the alternate hypothesis

$$H_A: \sigma^{\alpha}_{\omega^*_i} \neq \sigma^{\alpha}_{\omega^*_j} \tag{60}$$

which requires a two-tail test at the 5% and 1% levels, respectively.[194]

The results of this pair-wise comparison of the baseline methodologies for the <u>low</u> and <u>middle</u> values of $\hat{\omega}_{1970}$ are summarized in Tables 3.2 and 3.3 with asterisks (* and **) indicating significant differences at the 5% and 1% levels, respectively. The results of this comparison for the <u>high</u> value of $\hat{\omega}_{1970}$, as well as a summary of the number of significant pairwise comparisons for the five values of $\hat{\omega}_{1970}$ for each of the four alternative values of $\hat{\alpha}_{it}$, are provided in Table 3.4. Each pair-wise comparison for the ith and jth baseline methodologies in Tables 3.2, 3.3, and 3.4 is shown in each off-diagonal block, which is then divided into four sub-blocks (i.e., northwest, northeast, southeast, and southwest) that correspond to the estimates of $\hat{\alpha}_{it}$ by Stanley

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[194] The F_i-statistic in Equation (A-24) of Appendix A evaluates the null hypothesis H_o: $\theta_i = 0$ against the alternate hypothesis H_A: $\theta_i \neq 0$ which tests for "bias" in the ith estimating methodology. The F-statistic in Equation (58), on the other hand, tests the "relative efficiency" between the ith and jth estimating methodologies.

Table 3.2 Mean-Square-Error Ratios for the Pair-Wise Comparison of the Baseline Techniques for Estimating Soviet NSE Using Low Values of δ_{1970} [195]

$\delta_{1970} = 0$ / $\delta_{1970} = 5.5$	1		2		3		4		5		6		7		8		9		10	
	Official Soviet Defense Budget		Original Budgetary Technique (IISS Estimates)		FNE and BE Residuals Technique (SIPRI Estimates)		Revised Budgetary Technique (Stanley Cohn's Estimates)				Production Residual Estimation Techinque (Bill Lee's Estimates)				National Expenditure Method (French Estimates)		Direct Costing Technique (CIA Estimates)		External Information Method (Chinese Estimates)	
							State Reserves Basis		Final Demand Basis		Establishment Basis		Commodity Basis							
1. Official Soviet Defense Budget							*	*	*	*	*	*			*	*	*	*	*	*
							*	**	*	*		*			*	*	*	*		*
2. Original Budgetary Technique (IISS)								*												
								*										*		
3. FNE and BE Residuals (SIPRI)																				
4. Cohn Estimates (State Reserves Basis)	*	*	*	*		*														
	*	*	*	*	*	**							*	*						
5. Cohn Estimates (Final Demand Basis)																				
6. Lee Estimates (Establishment Basis)																				
7. Lee Estimates (Commodity Basis)							*	*		*										
							**	**	*	*								*		
8. National Expenditure Method (French Estimates)	*	*											*	*						
	*	*											*	*						
9. Direct Costing Technique (CIA Estimates)	*	*	*	*									*	*						
	*	*	*	**		*							$\boxed{*}$	**						
10. External Information Method (Chinese Estimates)																				

195 The low value of δ_{1970} used in the upper triangular matrix is John Pitzer's assumption that $\delta_{1970} = 0.$, and the low value of δ_{1970} used in the lower triangular matrix is Rush Greenslade's assumption that $\delta_{1970} = 5.5$ with the four alternative estimates of a_{it} represented in each off-diagonal block. The northwest, northeast, southeast, and southwest sub-block within each off-diagonal block correspond to the estimates of a_{it} by Stanley Cohn, a mixture (as reflected in Table 3.1), Bill Lee, and the CIA, respectively. The critical values of the F-statistic at the 5% level are .429 and 2.33, respectively, in each tail of the distribution, and the sub-block contains an asterisk when the mean-square-error ratio is outside this critical range. The critical values of the F-statistic at the 1% level are .296 and 3.37, respectively, in each tail of the distribution, and the sub-block contains two asterisks when the mean-square-error ratio is outside this critical range.

Table 3.3 Mean-Square-Error Ratios for the Pair-Wise Comparison of the Baseline Techniques for Estimating Soviet NSE Using Middle Values of Δ_{1970} [196]

$\Delta_{1970} = 8.6$ (upper) / $\Delta_{1970} = 11.7$ (lower)	1 Official Soviet Defense Budget		2 Original Budgetary Technique (IISS Estimates)		3 FNE and BE Residuals Technique (SIPRI Estimates)		4 Revised Budgetary Technique (Stanley Cohn's Estimates): State Reserves Basis		5 Revised Budgetary Technique (Stanley Cohn's Estimates): Final Demand Basis		6 Production Residual Estimation Technique (Bill Lee's Estimates): Establishment Basis		7 Production Residual Estimation Technique (Bill Lee's Estimates): Commodity Basis		8 National Expenditure Method (French Estimates)		9 Direct Costing Technique (CIA Estimates)		10 External Information Method (Chinese Estimates)	
1. Official Soviet Defense Budget							*	*							*	*	*	*		
							*	*							*	*	*	*		
2. Original Budgetary Technique (IISS)							*	*								*	*	*		
							*	*								*	*	*		
3. FNE and BE Residuals (SIPRI)							*			*						*		*		
							*	*							*	*	*	*		
4. Cohn Estimates (State Reserves Basis)	*	*	*	*	*	**							**	**						
	*	*	*	*	**	**					*	*	**	**						
5. Cohn Estimates (Final Demand Basis)													*	*						
					*	*							*	*						
6. Lee Estimates (Establishment Basis)							*	*												
							*	*												
7. Lee Estimates (Commodity Basis)							**	**	*	*					*	**	**	**		
							**	**	*	*					**	**	**	**		
8. National Expenditure Method (French Estimates)	*	*	*	*	*	*						*	*	**						
		*	*	*	*	*					*		**	**						
9. Direct Costing Technique (CIA Estimates)	*	*	*	*	*	*						**	**	**						
		*	*	*	*	*						*	**	**						
10. External Information Method (Chinese Estimates)							*	*												
							*	*												

[196] The middle value of Δ_{1970} used in the upper triangular matrix is the "mixture" $\Delta_{1970} = 8.6$, and the middle value of Δ_{1970} used in the lower triangular matrix is Bill Lee's $\Delta_{1970} = 11.7$ with the four alternative estimates of Δ_{it} represented in each off-diagonal block. The critical values of the F-statistic which are used to identify the sub-blocks with asterisks (* and **) are those previously defined in Footnote 195 of Table 3.2.

Table 3.4 Mean-Square-Error Ratios for the Pair-Wise Comparison of the Baseline Techniques for Estimating Soviet NSE Using High Values of $\hat{\omega}_{1970}$ [197]

$\hat{\omega}_{1970}$ = 25. / TOTAL	1		2		3		4		5		6		7		8		9		10	
	Official Soviet Defense Budget		Original Budgetary Technique (IISS Estimates)		FNE and BE Residuals Technique (SIPRI Estimates)		Revised Budgetary Technique (Stanley Conn's Estimates) State Reserves Basis		Revised Budgetary Technique (Stanley Conn's Estimates) Final Demand Basis		Production Residual Estimation Technique (Bill Lee's Estimates) Establishment Basis		Production Residual Estimation Technique (Bill Lee's Estimates) Commodity Basis		National Expenditure Method (French Estimates)		Direct Costing Technique (CIA Estimates)		External Information Method (Chinese Estimates)	
1. Official Soviet Defense Budget					**	**					**	**							**	**
					**	**					**	**							**	**
2. Original Budgetary Technique (IISS)	0	0			**	**	*	*			*			*					**	**
	0	0			**	**	*	*						**					**	**
3. FNE and BE Residuals (SIPRI)	1	1	1	1			**	**	**	**			**	**	**	**	**	**		
	1	1	1	1			**	**	**	**		*	**	**	**	**	**	**		
4. Cohn Estimates State Reserves Basis	4	4	4	5	3	3					**	**							**	**
	4	4	4	5	4	4					**	**							**	**
5. Cohn Estimates Final Demand Basis	1	1	0	0	1	2	0	0			**	*							**	**
	1	1	0	0	2	2	0	0			*	*							**	**
6. Lee Estimates Establishment Basis	2	2	1	0	0	0	2	2	1	1			**	**	**	**	**	**		
	1	2	0	0	0	1	3	3	1	1			**	**	**	**	*	*		
7. Lee Estimates Commodity Basis	0	0	0	1	1	1	3	3	2	3	1	1							**	**
	0	0	0	1	1	1	4	4	3	3	1	1							**	**
8. National Expenditure Method (French Estimates)	4	4	1	2	2	3	0	0	0	0	1	2	3	3					**	**
	3	4	1	2	3	3	0	0	0	0	2	1	3	3					**	**
9. Direct Costing Technique (CIA Estimates)	4	4	3	3	2	3	0	0	0	0	1	2	3	3	0	0			**	**
	3	4	3	4	3	4	0	0	0	0	1	2	3	4	0	0			**	**
10. External Information Method (Chinese Estimates)	2	2	1	1	0	0	2	2	1	1	0	0	1	1	1	1	1	1		
	1	2	1	1	0	0	2	2	1	1	0	0	1	1	1	1	1	1		

[197] As may be observed, this Table also presents a summary of the mean-square-error ratio terms using low, middle, and high values of $\hat{\omega}_{1970}$. The high value of $\hat{\omega}_{1970}$ used in the upper triangular matrix is Douglas Diamond's $\hat{\omega}_{1970}$ = 25.0. The lower triangular matrix contains the number of significant pair-wise comparisons for the five values of $\hat{\omega}_{1970}$ for each of the four alternative estimates of $\hat{a}_{it}$ represented in the off-diagonal blocks. The critical values of the F-statistic which are used to identify the sub-blocks with asterisks (* and **) are those previously defined in Footnote 195 of Table 3.2.

Cohn, a mixture (as reflected in Table 3.1), Bill Lee, and the CIA, respectively. For example, Experiment No. 17 in Table 3.1 compares the baseline estimation methodologies in terms of the estimates of $\hat{\beta}_{i,1970}$ with the "acceptance criteria" dependent upon the evaluation of each methodology separately as explained in Footnote 194. Inasmuch as Experiment No. 17 is based upon an assumption that $\hat{\omega}_{1970}$ = 5.5, then the pairwise comparisons between the ith and jth baseline methodologies are to be found in the lower triangular matrix of Table 3.2. Moreover, since Experiment No. 17 uses the CIA values for $\hat{\alpha}_{it}$, then the southwest sub-block of each off-diagonal block in the lower triangular matrix of Table 3.2 reflects the result of the F_{ij}-test in Equations (58), (59), and (60). In particular, Experiment No. 17 indicated that, as reflected in Row 17 and Columns 7 and 9 of Table 3.1, both the CIA and Bill Lee's commodity basis estimating techniques generated "acceptable" values for $\hat{\beta}_{i,1970}$. In this context, an examination of Row 9 and Column 7 in Table 3.2 reveals an asterisk in the southwest sub-block, which is identified by means of double lines and indicates that there is a significant difference between the "relative efficiency" of the CIA and Bill Lee's commodity basis estimating techniques under the conditions of Experiment No. 17 because the alternative hypothesis in Equation (60) must be accepted.[198] Therefore, from the standpoint of "relative bias" and in light of the "acceptable" estimates of $\hat{\beta}_{i,1970}$, the baseline methodologies in Experiment No. 17 are reduced to the CIA and Bill Lee's commodity basis techniques. Thus, from the standpoint of "relative efficiency", Bill Lee's commodity basis estimating technique would appear to be the best estimating methodology, if and only if, the assumptions underlying Experiment No. 17 are, in fact, correct. However, if the assumptions are changed to reflect the consideration of Experiment No. 18 in Table 3.1, then it may not be possible to statistically distinguish between the CIA and the Bill Lee's establishment basis estimating techniques (i.e., Row 18 and Columns 6 and 9 of Table 3.1). An examination of Row 6 and Column 9 in Table 3.3 reveal no asterisk in the southwest sub-block (identified by means of double lines), which indicates that there is no significant difference between the "relative

[198] The Bill Lee commodity basis mean-square-error is 13.08, whereas the CIA mean-square-error is 41.46 with the F-statistic in Equation (58) equal to 3.17--which is significant at the 5% level. Therefore, Bill Lee's commodity basis estimating technique is considered to be relatively more efficient than the CIA technique.

efficiency" of the CIA and Bill Lee's establishment basis estimating techniques under the conditions of Experiment No. 18 because the null hypothesis in Equation (59) must be accepted. The same evaluation procedure may be applied to all of the twenty resource allocation experiments defined in Appendix A.

In summary then, the ex post resource allocation analysis of the estimated level of Soviet NSE presented in this section of the report has:

- Provided a general ranking of the baseline methodologies in terms of their relative "robustness",
- Defined the relative bias and relative efficiency of the baseline estimation techniques, and
- Described a test for the relative efficiency of the baseline techniques under clearly identified experimental conditions.

However, the application of these two well-known properties of an estimator (i.e., relative bias and relative efficiency) for the purpose of identifying the best technique for estimating Soviet NSE is valid only if the assumptions associated with a given ex post resource allocation experiment are correct. Nonetheless, the empirical results based upon the methodology developed in Appendix A do provide an illustration of the various properties of estimators which are discussed in Section 2.10 of this summary report.

3.6 AN EX POST RESOURCE ALLOCATION ANALYSIS OF THE ESTIMATED COMPOSITION OF SOVIET NSE

This section of the summary report is devoted to an analysis of the disaggregation of Soviet NSE from the macro level to an appropriate micro level of detail, to include the development of a suitable classification taxonomy for analysis of the composition of Soviet NSE. In this context, the level of Soviet NSE may be conceptually disaggregated into Investment and Operating expenditures. Investment expenditures are of two general categories; namely,

- Capital expenditures for materiel, such as the procurement of new weapons, and
- Capital expenditures for human resources, such as military RDT&E. [199]

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[199] Military research, development, test and evaluation expenditures include the procurement of new technology.

Operating Expenditures may also be subdivided into two general categories; namely,

- Personnel costs, and
- Non-personnel costs.

Therefore, an initial conceptual taxonomy may be defined as follows:

- Investment expenditures, to include:
  - Capital expenditures for materiel (e.g., procurement), and
  - Capital expenditures for human resources (e.g., RDT&E).
- Operating expenditures, to include:
  - Personnel costs (e.g., compensation), and
  - Non-personnel costs (e.g., maintenance).

In general, there will be m categories of disaggregation at the micro level of detail for the macro level of Soviet NSE. Although the actual level of Soviet national security expenditures for a given time period and the jth micro level category (D^*_{tj}) is unknown, it may be related to the estimated level (D_{itj}) by means of the ith estimation technique as follows:

$$D_{itj} = D^*_{tj}\varepsilon_{itj} \text{ for } j = 1,\ldots, m \text{ categories} \tag{61}$$

where ε_{itj} is a stochastic "information error" term that is assumed to be lognormally distributed with the following mean and variance.[200]

$$E(\varepsilon_{itj}) = \exp(t\mu_{ij} + \tfrac{1}{2}\sigma_{ij}^2) \quad \text{and} \tag{62}$$

$$V(\varepsilon_{itj}) = \exp(2t\mu_{ij} + \sigma_{ij}^2)[\exp(\sigma_{ij}^2)-1] \tag{63}$$

As a result, the natural logarithm of ε_{itj} will have a normal distribution with the following mean and variance:

$$E(\ln\varepsilon_{itj}) = t\mu_{ij} \text{ and } V(\ln\varepsilon_{itj}) = \sigma_{ij}^2 \tag{64}$$

for j = 1,..., m categories.

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200 E. Parzen, Modern Probability Theory and Its Application, Wiley, New York, 1960, page 348. The assumption of lognormality is appropriate, if the effect of the information error ε_{itj} is directly proportional to the magnitude of the actual level of Soviet NSE in the jth micro level category, D^*_{tj}--H. Cramer, Mathematical Methods of Statistics, Princeton University, Press, 1966, page 220.

Therefore, the average information error for the ith estimation technique and the jth micro level category of disaggregation will depend upon the value of the parameter μ_{ij} and the time period t. The variance of the information error is constant for all time periods.

It is also hypothesized that the actual level of Soviet NSE for a given time period and for the jth micro level category may be conceptually related to a base year (i.e., t = 0) parameter a_{ij} and a growth percentage parameter b_{ij} using the ith estimation technique as follows:

$$D^*_{tj} = a_{ij} b^t_{ij} \upsilon_{itj} \text{ for } j = 1, \ldots, m \text{ categories}, \tag{65}$$

where υ_{itj} is a stochastic "methodology error" term.

Now assuming that υ_{itj} is lognormally distributed with the following mean and variance[201]

$$E(\upsilon_{itj}) = \exp(\omega_{ij} + \tfrac{1}{2}\lambda^2_{ij}), \text{ and} \tag{66}$$

$$V(\upsilon_{itj}) = \exp(2\omega_{ij} + \lambda^2_i)\,[\exp(\lambda^2_{ij}) - 1] \tag{67}$$

then the natural logarithm of υ_{itj} will have a normal distribution with the following mean and variance:

$$E(\ln \upsilon_{itj}) = \omega_{ij} \text{ and } V(\ln \upsilon_{itj}) = \lambda^2_{ij} \tag{68}$$

for j = 1,..., m categories.

Therefore, the average methodology error for the ith estimation technique and the jth micro level category of disaggregation will depend upon the value of the parameter ω_{ij}. The variance of the methodology error is constant for all time periods.

By substituting Equation (65) into Equation (61), the following micro level operational equation for the ith estimation technique will result:

[201] The assumption of lognormality is appropriate, if the effect of the methodology error υ_{itj} is directly proportional to the $a_{ij}b^t_{ij}$ level of Soviet defense spending in the jth micro level category. Definitions of information error and methodology error terms were previously introduced in Section 2.10 of this summary report.

$$D_{itj} = a_{ij} b_{ij}^{t} u_{itj} \varepsilon_{itj} \quad \text{for } j = 1, \ldots, m \text{ categories.} \qquad (69)$$

In this equation, the micro level "rate of growth" parameters are defined as follows:[202]

$$r_{ij} = b_{ij} - 1 \quad \text{for } j = 1, \ldots, m \text{ categories.} \qquad (70)$$

These conceptual micro level categories of disaggregation of Soviet NSE with their associated information and methodology error terms may now be operationally implemented.

3.6.1 Implementation of Conceptual Micro Level Categories of Disaggregation of Soviet NSE

The CIA provides estimates of Soviet national security expenditures (NSE), as well as estimates of the composition of this NSE in terms of the following categories:

- Spending by the branches of service:
  - Ground Forces,
  - Air Forces,
  - Navy,
  - National Air Defense Forces (PVO),
  - Strategic Rocket Forces, and
  - Command and Support.
- Spending by specific missions:
  - Intercontinental attack forces subject to SALT II limitations,
  - Soviet forces in the NATO guidelines area, and
  - Forces along the Sino-Soviet border.
- Spending by resource categories:
  - Investment expenditures,
  - Operating expenditures, and
  - Research, Development, Testing, and Evaluation (RDT&E) expenditures.[203]

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[202] The micro level categories of disaggregation in Appendix B are defined as $m = 12$ sectors of the economy with the "conceptual" parameter r_{ij} estimated in Table B-33.

[203] CIA, Estimated Soviet Defense Spending: Trends and Prospects, SR 78-10121, June 1978, pages 2-8.

For purposes of this ex post resource allocation analysis and consistent with current perceptions of the composition of Soviet NSE, the disaggregation of Soviet NSE by means of the foregoing resource categories will be emphasized, and the following set of "disaggregation rules" for correlating each resource category with a particular sector(s) of the Soviet economy will be utilized:

- The Investment expenditures category generally includes spending for the:[204]
  - Procurement of new equipment and weapons,
  - Procurement of major spare parts, and
  - Construction of facilities.
- The Operating expenditures category may be generally disaggregated into military personnel costs, to include:
  - Pay and allowances and retirement pay,
  - Food, and
  - Personal equipment, medical care, and travel;

  and operation and maintenance costs, to include:
  - Maintenance of equipment and facilities,
  - Purchase of petroleum, lubricants, and utilities,
  - Hiring civilian personnel, and
  - Leasing of communications.
- The RDT&E expenditures category generally includes:
  - Wages and social insurance,
  - Prototypes of new equipment,
  - Fuels, chemicals, and other materiel inputs, and
  - Plant and equipment facilities.

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204 Ibid., Footnote 3, page 2. The recent CIA investment expenditures analysis is still based upon the "narrow definition" of defense which corresponds to that used in the United States. However, in disaggregating NSE in terms of resource categories, the CIA is now using a "wider definition" of investment, and a "narrower definition" of operating costs, than is currently employed in describing U.S. defense accounts. These CIA definitions now assign a greater share of spending for spare parts and repair to investment and a lesser share to operating costs than was the case in the CIA document Estimated Soviet Defense Spending in Rubles, 1970-1975, SR 76-101210, May 1976.

In light of the foregoing "disaggregation rules," the Investment expenditures resource category may be generally associated with the Machine-Building and Metalworking sectors for the procurement of new weapons, as well as spare parts. This category may also be associated with the Construction sector for the building of new facilities and with the Transportation and Communications sector for support equipment.

The Operating expenditures resource category may be associated directly with the Food and the Light Industry sectors from the standpoint of food for military personnel, personal equipment, medical care, and travel. This category may also be associated with the:

- Food and the Light Industry sectors from the standpoint of military pay and allowances, retirement pay, and the wages and salaries of civilian personnel--but only indirectly after these wages and salaries are spent;[205]
- Fuels and Chemicals and Petrochemicals sectors for the purchase of petroleum, lubricants, and utilities required for the maintenance of equipment and facilities;
- Transportation and Communications sector for the leasing of communications equipment.

The RDT&E expenditures resource category may be generally associated with the Machine-Building and Metalworking sectors for the prototypes of new equipment. This category may also be associated with the:

- Fuels and the Chemicals and Petrochemicals sectors for the purchase of materiel inputs;
- Food and Light Industry sectors from the standpoint of wages and social insurance--but again, only indirectly after this compensation is spent;
- Construction sector for the building of new plant and equipment facilities.

The foregoing general description of the functional relationships between each resource expenditure category and various sectors of the Soviet economy is summarized in Table 3.5. The zero entries indicate those sectors

[205] Alternative assumptions with respect to the consumption pattern of wages, salaries, and other compensation between the Food and Light Industry sectors will be discussed later in this section of the summary report.

Table 3.5 A Summary of the General Disaggregation of Estimated Soviet Defense Spending by Resource Expenditure Category and Economic Sector [207]

1		2	3	4	5
Economic Sectors		Resource Categories			Row Sum ($d^i_t D_{it}$)
Number	Activity	Investment Expenditures (x^i_{jt})	Operating Expenditures (y^i_{jt})	RDT&E Expenditures (z^i_{jt})	
1	Agriculture	0	0	0	0
2	Fuels (i.e., electric power, coal, oil and gas)	0	y^i_{2t}	z^i_{2t}	$y^i_{2t}+z^i_{2t}$
3	Metals (i.e., ferrous and non-ferrous)	0	0	0	0
4	Machinery and Equipment (i.e., machine-building)	x^i_{4t}	0	z^i_{4t}	$x^i_{4t}+$ z^i_{4t}
5	Other Machinery and Equipment (i.e., metalworking)	x^i_{5t}	0	z^i_{5t}	$x^i_{5t}+$ z^i_{5t}
6	Construction Materials	0	0	0	0
7	Chemicals and Petrochemicals	0	y^i_{7t}	z^i_{7t}	$y^i_{7t}+z^i_{7t}$
8	Food Industry	0	y^i_{8t}	z^i_{8t}	$y^i_{8t}+z^i_{8t}$
9	Light Industry	0	y^i_{9t}	z^i_{9t}	$y^i_{9t}+z^i_{9t}$
10	Construction	x^i_{10t}	0	z^i_{10t}	$x^i_{10t}+$ z^i
11	Transport and Communications	x^i_{11t}	y^i_{11t}	0	$x^i_{11t}+y^i_{11t}$
12	Trade and Distribution	0	0	0	0
	Column Sum	$x^i_{.t}$	$y^i_{.t}$	$z^i_{.t}$	$x^i_{.t}+y^i_{.t}+z^i_{.t} = D_{it}$

[207] Definitions of the sums of the columns in Table 3.5 are as follows:

- Column 2: $x^i_{.t} = x^i_{4t}+x^i_{5t}+x^i_{10t}+x^i_{11t}$ is the estimated portion of Soviet NSE allocated for Investment expenditures by the ith estimating technique in time period t.
- Column 3: $y^i_{.t} = y^i_{2t}+y^i_{7t}+y^i_{8t}+y^i_{9t}+y^i_{11t}$ is the estimated portion of Soviet NSE allocated for Operating expenditures by the ith estimating technique in time period t.
- Column 4: $z^i_{.t} = z^i_{2t}+z^i_{4t}+z^i_{5t}+z^i_{7t}+z^i_{8t}+z^i_{9t}+z^i_{10t}$ is the estimated portion of Soviet NSE allocated for RDT&E expenditures by the ith estimating technique in time period t.
- Column 5: $D_{it} = x^i_{.t}+y^i_{.t}+z^i_{.t}$ is total level of Soviet NSE, which is the sum of the:
  - Three aggregate resource expenditure categories, or
  - Twelve aggregate economic sectors, or
  - Sixteen identified, disaggregated resource expenditure categories by economic sectors--discounting the twenty negligible entries identified by means of a zero.

in which direct military expenditures are generally considered to be negligible.[206] As may be observed, only four of the twelve sectors contain zero entries for all three resource expenditure categories--namely,

- Sector 1: Agriculture,
- Sector 3: Metals (ferrous and non-ferrous),
- Sector 6: Construction Materials, and
- Sector 12: Trade and Distribution.

The explanation for these zero entries in Column 5 of Table 3.5 is that each of these four economic sectors represents dominant intersectoral inputs into four other economic sectors which absorb the direct military purchases. For example, the Agricultural sector provides the dominant intersectoral input into the Food sector--which may be verified in Table B-1 of Appendix B wherein the Agricultural row multiplier for the Food column exceeds all other multipliers in Row 1 or Column 8 of Table B-1, except their "own" multipliers.[207] In a similar fashion, the Metals sector represents the dominant intersectoral input into the Machine-Building and Metalworking (MBMW) composite sector (i.e., sectors 4 and 5)--which is also verified in Table B-1 of Appendix B wherein the Metals row multipliers for Columns 4 and 5 exceed all other multipliers in Row 3 or in Columns 4 and 5, expect their "own" multipliers. In the same way, the Construction Materials sector represents th dominant intersectoral input into the Construction sector--which is again verified in Table B-1 of Appendix B wherein the Construction Materials row multiplier for the Construction column exceeds all other multipliers in

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[206] For purposes of this analysis of Soviet resource allocation and in light of the sample data presented in Tables B-7a, B-7b, B-8a, and B-8b of Appendix B, a negligible level of expenditures is defined as less than 2% of the total estimated Soviet NSE.

[207] The Agricultural row multiplier for Food in producer's prices is 0.9318, which clearly dominates all of the entries in Row 1--except that for Agriculture. In addition, it clearly dominates all of the entries in Column 8--except that for Food. The same dominance characteristics are also reflected in Table B-34 but, in purchaser's prices, the multiplier is only 0.6442.

Row 6 of Column 10, except their "own multipliers".[208]

The foregoing explanation of dominant intersectoral inputs does not apply to the Trade and Distribution sector because the Soviet Armed Forces have their own facilities for handling goods and services required for military purposes, so there are no direct military expenditures in the Trade and Distribution sector. However, this sector is affected indirectly by Soviet defense spending, as are all of the other sectors, in terms of the input-output requirements among the 12 sectors. To recapitulate, since Agriculture is dominated by the Food sector, Metals is dominated by the MBMW composite sector, and Construction Materials is dominated by the Construction sector, then nine of the twenty zero entries in Columns 2, 3, and 4 of Table 3.5 reflect this dominance characteristic. On the other hand, the three zero entries for the Trade and Distribution sector and the remaining eight zero entries in Columns 2, 3, and 4 of Table 3.5 reflect the lack of direct military expenditures in those respective sectors. For example, the Fuels, Chemicals, Food, and Light Industry sectors will not be involved in Investment expenditures, but they are involved in Operating and RDT&E expenditures. Similarly, the Machine-Building, Metalworking, and Construction sectors will not be involved in Operating expenditures, but they will be involved in Investment and RDT&E expenditures. Finally, the Transport and Communication sector is not particularly involved in RDT&E expenditures, but it is involved in Investment and Operating expenditures. These zero entries in Columns 2, 3, and 4 of Table 3.5 will greatly simplify the analyst's task of disaggregating the total estimated level of Soviet NSE into three resource expenditure categories ($x^i_{.t}$, $y^i_{.t}$, and $z^i_{.t}$) and then into sixteen micro level resource expenditure categories by economic sectors (i.e., $4x^i_{jt}$, $5y^i_{jt}$, and $7z^i_{jt}$). Inasmuch as the distribution of Soviet NSE (excluding RDT&E expenditures)

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208 The Metals row multipliers for Machine-Building and for Metalworking in Table B-2 in producer's prices are 0.2774 and 0.3755, respectively. These values clearly dominate all of the entries in Row 3, except that for Metals, and they clearly dominate all of the entries in Columns 4 and 5, except that for the composite MBMW in Rows 4 and 5. The same dominance characteristics are also reflected in Table B-34 but, in purchaser's prices, the multipliers are only 0.2693 and 0.3597, respectively. The Construction Materials row multiplier for Construction in Table B-1 is 0.3485, which clearly dominates all entries in Row 6, except that for Construction Materials. It also clearly dominates all entries in Column 10, except that for Construction. The same dominance characteristics are also reflected in Table B-34 and, in purchaser's prices, the multiplier is almost identical to that in producer's prices (e.g., 0.3491).

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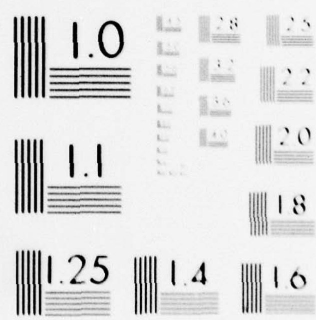

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

involves nine sectors which, with the exception of Transport and Communications are mutually exclusive with respect to Investment and Operating expenditures, it is appropriate to initially focus upon the sectoral disaggregation represented by $x^i_{jt} + y^i_{jt}$ for j = 1,..., 12 sectors. The distribution of RDT&E expenditures among the seven sectors identified in Column 4 of Table 3.5 may be added to the foregoing initial distribution in order to produce the sectoral disaggregation of Soviet NSE, including RDT&E expenditures, for the period t with the ith estimation technique. In this context, it should be noted that Bill Lee's data in Tables B-7a and B-7b of Appendix B, as well as Stanley Cohn's data in Tables B-8a and B-8b, were obtained in this manner. Unfortunately, the sectoral disaggregation rules reflected in Table 3.5 were not completely satisfied by either Bill Lee or Stanley Cohn for the following reasons:

- In Bill Lee's case, he <u>understates</u> the y^i_{8t} and y^i_{9t} entries in Table 3.5 because military pay, allowances, and retirement expenditures were not included. Only the estimated Soviet expenditures on military food, personal equipment, medical care, and travel are included in the y^i_{8t} and y^i_{9t} entries. Moreover, Bill Lee does <u>not</u> estimate the x^i_{11t} and y^i_{11t} entries for Transport and Communication expenditures separately in Table 3.5. Finally, Bill Lee does <u>not</u> estimate the z^i_{8t} and z^i_{9t} entries in Table 3.5 because all wages and social insurance expenditures for RDT&E personnel have been omitted, as indicated in Table B-7b of Appendix B.[209] These methodological inconsistencies in Bill Lee's disaggregation of his estimated level of Soviet NSE by economic sector reflects the need for the general disaggregation rules utilized in Table 3.5. It should also be noted that, even when the disaggregation rules utilized in this summary report are satisfied, the possibilities of information errors in estimated values of x^i_{jt}, y^i_{jt}, and z^i_{jt} still exist.

- In Stanley Cohn's case, violation of the general disaggregation rules is more subtle as may be revealed by an examination of Tables B-8a and B-8b in Appendix B. First, the y^i_{7t} and z^i_{7t} entries for the Chemicals and Petrochemicals sector are <u>not</u> separately estimated and, second, the y^i_{2t} and z^i_{2t} entries for the Fuels sector are unusually high by comparison with the

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209 These apparent violations of the "disaggregation rules" utilized in this summary report have been inferred on the basis of data presented in Table A-1 and statements on page 6 of Steven Rosefielde's draft paper on <u>A Preliminary Net Assessment of the Civilian Labor Force Devoted to the Production of Defense Goods in the United States and the Soviet Union</u>, GE-TEMPO GE 76 TMP-54B, October 1977.

same entries in Tables B-7a and B-7b. It is therefore hypothesized that Stanley Cohn overstated the y^i_{2t} and z^i_{2t} entries in Table 3.5 by including the y^i_{7t} and z^i_{7t} entries and effectively combining the Fuels and the Chemicals sectors into a single composite sector. Thirdly, the Food and Light Industry sectors reflect alternative assumptions with regard to the distribution of spending for food and non-food items by those who receive military pay, allowances, retirement pay, wages, and social insurance. A recent empirical study of Soviet consumption patterns reveals the following percentage distributions of all Soviet consumption expenditures for the year 1970:[210]

- Food sector: 49 percent,
- Light Industry sector: 27 percent, and
- Services: 24 percent.

Because services are not explicitly represented in Table 3.5, one hypothesis is that the long-run expenditure "feedback" into the Food and Light Industry sectors from initial expenditures on services will yield the following consumption pattern:[211]

- Food sector: 64 percent, and
- Light Industry sector: 36 percent.

An alternative hypothesis is that Soviet military personnel tend to spend a smaller percentage of their pay on food than do civilian personnel because Soviet military personnel already receive food, personal equipment, and medical care as fringe benefits. Therefore, it may reasonably be inferred that Soviet military personnel will spend a larger percentage of their pay on non-food items than do civilian personnel. Consequently, an alternative consumption pattern is as follows:[212]

- Food sector: 50 percent, and
- Light Industry sector: 50 percent.

Both of these alternative hypotheses are included in Stanley Cohn's sectoral disaggregation of his estimates for Soviet NSE in Tables B-8a and B-8b of Appendix B.

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210 G.E. Schroeder and B.S. Severin, "Soviet Consumption and Income Policies in Perspective," Joint Economic Committee report, October 1976, Table 3, pages 649-650.

211 The long-run expenditure multiplier for services [i.e., 1/(1.-.24)=1.316] multiplied by the original percentage for Food expenditures and the percentage for Light Industry expenditures produces the feedback percentage [i.e., (1.316)(.49)=.64 and (1.316)(.27)=.36].

212 The formal justification for this alternative hypothesis is that the original distribution of all Soviet consumption expenditures for Soviet military personnel is as follows: Food sector--38 percent, Light Industry sector--38 percent, and Services--24 percent. Consequently, the long-run expenditure multiplier for services [i.e., 1/(1.-.24)=1.316] multiplied by the equal expenditure percentage for Food and for Light Industry produce the feedback percentages [i.e., (1.316)(.38)=(.50)].

3.6.2 A Demonstration of the General Disaggregation Rules

Application of the general disaggregation rules reflected in Table 3.5 may be demonstrated by distributing the CIA direct costing estimate of Soviet NSE for 1970 among the twelve Soviet economic sectors listed in Column 1 of the same table. Moreover, inasmuch as the CIA has defined Investment, Operating, and RDT&E expenditures as principal resource categories, they will also be used in the estimation of the sixteen disaggregated resource expenditure categories identified in Columns 2, 3, and 4 of Table 3.5. The direct costing estimate of Soviet NSE for the year 1970 is defined by the CIA as follows:

> In this report, two possible definitions are postulated. Using a definition which encompasses a range of activities comparable to those included in the US budgetary definition of defense, it is estimated that the USSR spent some 40-45 billion rubles in 1970 and that in 1975 total outlays for these purposes had risen to 50-55 billion rubles, measured in constant 1970 rubles. Under a broader definition--one which the Soviets might use and which would include additional military-operated programs such as the entire space program--it is estimated that total defense spending amounted to 45-50 billion rubles in 1970 and rose to 55-60 billion rubles in 1975. [212]

The purpose of this demonstration of the numerical implementation of the general disaggregation rules using the unclassified information for the year 1970 presented in CIA's unclassified report cited in Footnote 212 is to develop a possible <u>time series</u> sectoral disaggregation of Soviet NSE for the period 1967-1977 based upon CIA's recent unclassified report cited in Footnote 203. For purposes of this demonstration, the <u>narrow</u> definition of Soviet defense spending for the year 1970 will be used with the low, middle, and high estimates of D_{7t} equal to 40.0, 42.5, and 45.0, respectively. In this context, estimates of the Column Sums in Table 3.5 are as follows:[213]

- $x^7_{.t}$ = 54 percent of D_{7t} for Investment Expenditures,
- $y^7_{.t}$ = 26 percent of D_{7t} for Operating Expenditures, and
- $z^7_{.t}$ = 20 percent of D_{7t} for RDT&E Expenditures.

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[212] Op. Cit., CIA's report on <u>Estimated Soviet Defense Spending in Rubles, 1970-1975</u>, SR 76-101210, page 7.

[213] Ibid., page 13. These estimates are based upon the "wider definition" of Investment and the "narrower definition" of Operating Expenditures described in Footnote 204. The original estimates were $x^7_{.t} = y^7_{.t}$ = 40 percent and $z^7_{.t}$ = 20 percent.

The term $x^7_{.t}$, which corresponds to 54% of D_{7t} (i.e., the estimated Soviet Investment Expenditures related to NSE), may now be disaggregated into its four component elements as follows:

- x^7_{4t} = 16.5 percent of D_{7t},
- x^7_{5t} = 30.5 percent of D_{7t},
- x^7_{10t} = 4 percent of D_{7t}, and
- x^7_{11t} = 3 percent of D_{7t}.

Derivation of the foregoing estimates may be summarized as follows:[214]

- x^7_{4t} reflects one-half of the 33 percent procurement of new weapons;
- x^7_{5t} reflects the other one-half of the 33 percent procurement of new weapons, plus the spare parts required to maintain the stocks of weapons and equipment; but inasmuch as spare parts represent 35 percent of Operating Expenditures, then 35 percent of the 40 percent cited in Footnote 213 is actually 14 percent of D_{7t};
- x^7_{10t} reflects the construction of facilities, for which 10 percent of the 40 percent previously cited is 4 percent of D_{7t}; and
- x^7_{11t} is computed as a residual where $x^7_{11t} = \left(x^7_{.t} - x^7_{4t} - x^7_{5t} - x^7_{10t} \right)$.

Similarly, the term $y^7_{.t}$, which corresponds to 26 percent of D_{7t} (i.e., the estimated Soviet Operating Expenditures related to NSE), may be disaggregated into the five component elements as follows:[214]

- y^7_{2t} = 2 or 3 percent of D_{7t},
- y^7_{7t} = 2 or 3 percent of D_{7t},
- y^7_{8t} = 10 or 11 percent of D_{7t},
- y^7_{9t} = 10 or 9 percent of D_{7t}, and
- y^7_{11t} = less than 2 percent of D_{7t}.

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214 Ibid., pages 13 and 15.

Derivation of the foregoing estimates may be summarized as follows:

- Inasmuch as Operating Expenditures consist of one-half personnel costs and the other half non-personnel costs, then 20 percent of D_{7t} constitute personnel costs (i.e., original estimates);

- If military pay and allowances are <u>less</u> than half of the personnel costs (i.e., 2/5 of 20 percent of D_{7t}) and if military food, personal equipment, medical care, and travel are <u>more</u> than half of personnel costs (i.e., 3/5 of 20 percent of D_{7t}), then y^7_{8t} and y^7_{9t} will depend upon a hypothetical division of the expenditure of military pay and allowances between the Food and Light Industry sectors in the long run;

- Because a hypothesized division of, say, 64 percent/36 percent will only influence 2/5 of 20 percent of D_{7t} (i.e., the remaining 3/5 of 20 percent of D_{7t} may be assumed to be equally divided between the Food and Light Industry sectors), then the range of values for y^7_{8t} will be from 10 to 11 percent of D_{7t} [i.e., (.50)(.4)(.2) + (.50)(.6)(.2) versus (.64)(.4)(.2) + (.50)(.6)(.2)] and the range of values for y^7_{9t} will be from 10 to 9 percent of D_{7t} [i.e., (.50)(.4)(.2) + (.50)(.6)(.2) versus (.36)(.4)(.2) + (.50)(.6)(.2)];

- Once again, since 20 percent of D_{7t} consists of non-personnel costs, then subtracting x^7_{5t} (where spare parts represent 14 percent of D_{7t}) will yield only 6 percent of D_{7t} for distribution among y^7_{2t}, y^7_{7t}, and y^7_{11t} (i.e., Fuels, Chemicals, and Transport and Communication ; and

- Because Fuels and Chemicals will absorb most of this 6 percent of D_{7t}, then y^7_{11t} may be considered to be negligible and therefore set to zero, while y^7_{2t} may be assumed to equal y^7_{7t}.[215]

Finally, the term $z^7_{.t}$, which corresponds to 20 percent of D_{7t} (i.e., the estimated Soviet RDT&E Expenditures related to NSE), may also be disaggregated into six of its seven component elements as follows:[216]

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[215] These assumptions may be subject to change on the basis of classified information.

[216] Op. Cit., William T. Lee, <u>The Estimation of Soviet Defense Expenditures, 1955-1975: An Unconventional Approach</u>, Table D.16, page 293.

- z^7_{2t} = less than 2 percent of D_{7t},
- $z^7_{4t}+z^7_{5t}$ = 8 percent of D_{7t},
- z^7_{7t} = less than 2 percent of D_{7t},
- z^7_{8t} = 3.3 or 4.2 percent of D_{7t},
- z^7_{9t} = 3.3 or 2.4 percent of D_{7t}, and
- z^7_{10t} = 4.4 percent of D_{7t}.

Initially, the value of $z^7_{.t}$ may be disaggregated into the following four major components:

- The Wage Bill (i.e., 32 percent), which corresponds to $z^7_{8t}+z^7_{9t}$;
- Prototypes (i.e., 40 percent), which corresponds to $z^7_{4t}+z^7_{5t}$;
- Investment in R&D Plant facilities (i.e., 22 percent), which corresponds to z^7_{10t}; and
- Other Material Inputs (i.e., 6 percent), which corresponds to $z^7_{2t} + z^7_{7t}$.[216]

The foregoing percentages are estimated for the year 1970, whereas the value of z^7_{8t} in the Wage Bill component is estimated separately by means of a hypothesized 64 percent/36 percent division of the expenditures of wages and social insurance between the Food and Light Industry sectors over the long term. The other end point in the range of values z^7_{8t} is obtained by means of a hypothesized 50 percent/50 percent division of these expenditures. Therefore, the range of values for z^7_{8t} will be from 3.3 to 4.2 percent of D_{7t} [i.e., (.50)(.32)(.2) versus (.64)(.32)(.2)], and the range of values for z^7_{9t} will be from 3.3 to 2.4 percent of D_{7t} [i.e., (.50)(.32)(.2) versus (.36)(.32)(.2)]. The sum, $z^7_{4t} + z^7_{5t}$, is then estimated directly from the Prototypes component as 8 percent of D_{7t} [i.e., (.4)(.2)]. Inasmuch as prototypes may be largely confined to the Machine-Building sector, then z^7_{4t} will be almost 8 percent of D_{7t} and z^7_{5t} may be considered negligible.[217] The estimated value of the third major component of $z^7_{.t}$ (i.e., Investment in R&D Plant facilities) is 4.4 percent of D_{7t} [i.e., (.22)(.2)]. Finally, the estimated value of z^7_{2t}

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[216] Op. Cit., William T. Lee.

[217] Again, subject to change on the basis of classified information.

is 0.1 billion rubles for the year 1970, and the estimated value for z^7_{7t} is 0.3 billion rubles, also for the year 1970.[218] Inasmuch as both z^7_{2t} and z^7_{7t} are less than 2 percent of D_{7t}, they might also be considered "negligible" and set to zero. However, since national estimates have been obtained for these two terms, they should be used, despite their relatively small magnitude.

A numerical implementation of the foregoing general disaggregation rules for the year 1970, based upon an unclassified source of information describing the CIA's direct costing estimates, is presented in Table 3.6. Although these general disaggregation rules are meant to provide some guidance for the analyst, the exact percentage of D_{it} to be associated with each of the resource expenditure categories (x^i_{jt}, y^i_{jt}, and z^i_{jt}) for the jth economic sector will depend upon the analyst's judgment and the information available. However, in light of these general rules of disaggregation, it is possible to modify the original disaggregation of Bill Lee's estimates of Soviet NSE presented in Tables B-7a and B-7b of Appendix B for the purpose of correcting two serious methodology errors.

3.6.3 Application of the General Disaggregation Rules

Bill Lee's underestimate of expenditures in the Food and Light Industry sectors may be corrected by including military pay, allowances, all wages for RDT&E, and social insurance expenditures. These categories of personnel compensation may then be divided between food and soft goods on the basis of the 64 percent/36 percent hypothesis or the 50 percent/50 percent hypothesis. In addition, Bill Lee's overestimate of expenditures in the Machine-Building and Metalworking sectors may be corrected by replacing his high establishment basis estimates for weapons procurement with his lower commodity basis estimates. Some recent empirical evidence presented by Robert J. Abbott and identified in Footnote 114 on page 82 of this summary report supports the replacement of Bill Lee's establishment basis estimates with his commodity basis estimates for Soviet national security (NS) durables. Based upon these corrections, modified

[218] Op. Cit., Steven Rosefielde, GE-TEMPO draft report (GE 76 TMP-54B), Table A-2, page A-2. These national estimates were developed by Bill Lee for Steven Rosefielde.

Table 3.6 A Disaggregation of the Direct Costing Estimate for Soviet National Security Expenditures for the Year 1970 by Economic Sector[219]

(billions of rubles)

1		2	3	4	5	6	7
Economic Sector		Low Estimate		Middle Estimate		High Estimate	
		without RDT&E	with RDT&E	without RDT&E	with RDT&E	without RDT&E	with RDT&E
		$(x^7_{jt}+y^7_{jt})$	$(d^7_t D_{7t})$	$(x^7_{jt}+y^7_{jt})$	$(d^7_t D_{7t})$	$(x^7_{jt}+y^7_{jt})$	$(d^7_t D_{7t})$
1	Agriculture	0	0	0	0	0	0
2	Fuels (i.e., electric power, coal oil and gas)	1.2	1.3	1.27	1.37	1.35	1.45
3	Metals (i.e., ferrous and non-ferrous)	0	0	0	0	0	0
4	Machinery and Equipment (Machine-Building)	6.6	8.2	7.0	8.7	7.4	9.2
5	Other Machinery and Equipment (Metalworking)	12.2	13.8	12.95	14.65	13.7	15.5
6	Construction Materials	0	0	0	0	0	0
7	Chemicals and Petrochemicals	1.2	1.5	1.28	1.58	1.35	1.65
8	Food Industry	4.4 (4.0)	6.1 (5.3)	4.75 (4.25)	6.55 (5.65)	5.1 (4.5)	7.0 (6.0)
9	Light Industry	3.6 (4.0)	4.5 (5.3)	3.75 (4.25)	4.75 (5.65)	3.9 (4.5)	5.0 (6.0)
10	Construction	1.6	3.4	1.7	3.6	1.8	3.8
11	Transport and Communication	1.2	1.2	1.3	1.3	1.4	1.4
12	Trade and Distribution	0	0	0	0	0	0
Column Sum		32.0	40.0	34.0	42.5	36.0	45.0

[219] Sources of the data presented in Table 3.6 are as follows:

- Column 2 is based upon the general disaggregation rules for x^7_{jt} and y^7_{jt} with the additional constraint that y^7_{11t} is zero when D_{7t} is 40.0 billion rubles.
- Column 3 is derived from the entries in Column 2 plus the general disaggregation rules for z^7_{jt}, with the additional constraint that z^7_{5t} is zero when D_{7t} is 40.0 billion rubles.
- Column 4 is based upon the general disaggregation rules for x^7_{jt} and y^7_{jt} with the additional constraint that y^7_{11t} is zero when D_{7t} is 42.5 billion rubles.
- Column 5 is derived from the entries in Column 4 plus the general disaggregation rules for z^7_{jt}, with the additional constraint that z^7_{5t} is zero when D_{7t} is 42.0 billion rubles. The sectoral disaggregation in this column corresponds to the level of D_{7t} for the year 1970 in Column 10 of Table 2.22.
- Column 6 is based upon the general disaggregation rules for x^7_{jt} and y^7_{jt}, with the additional constraint that y^7_{11t} is zero when D_{7t} is 45.0 billion rubles.
- Column 7 is derived from the entries in Column 6 plus the general disaggregation rules for z^7_{jt}, with the additional constraint that z^7_{5t} is zero when D_{7t} is 45.0 billion rubles.

The entries for the Food and Light Industry sectors <u>without</u> parentheses reflect the hypothesis that wages and social insurance are spent <u>64</u> percent on food and 36 percent on soft goods. On the other hand, the entries for these sectors <u>with</u> parentheses reflect the hypothesis that wages and social insurance are spent <u>50</u> percent on food and 50 percent on soft goods.

estimates of Bill Lee's sectoral disaggregation of Soviet NSE are presented in Tables 3.7 and 3.8.

The correction of Bill Lee's underestimate of Sectors 8 and 9 is approximately the same magnitude as his overestimate of Sectors 4 and 5. This statement may be confirmed by comparing the Total row in Tables B-7a and 3.7, wherein RDT&E Expenditures are excluded, as well as the Total row in Tables B-7b and 3.8, wherein RDT&E Expenditures are included. The modified estimates of Soviet NSE by sectors in Tables 3.7 and 3.8 not only are complete in a definitional sense, but also are in closer agreement with Stanley Conn's estimates of Soviet NSE by sectors in Tables B-8a and B-8b in Appendix B.

Now, it is appropriate to re-examine Steven Rosefielde's preliminary conclusions based upon his computational methodology, which is described in Appendix B, and Bill Lee's original estimates of Soviet NSE by sectors in Tables B-7a and B-7b in Appendix B. The revisions in these sectoral expenditure estimates on the basis of the general disaggregation rules which have been presented in this section of the report and the review of the baseline estimation methodologies in the preceding sectors of this report have important consequences with respect to Steven Rosefielde's results.[220] In addition, the extension of the Soviet burden analysis to capital resources provides a more complete evaluation of the burden of Soviet NSE upon all resources. In this context, Steven Rosefielde provides the following summary in his draft report:

> To summarize, the preliminary phase of this research on the magnitude and structure of civilian Soviet manpower employed in defense production has revealed that:
>
> - The input-output approach, which has been defined, is feasible;
> - In 1970 (the year in which the estimate of Soviet NSE is considered to be most accurate), some 8.7 million manyears were devoted to the production of defense (excluding RDT&E) and 11.9 million manyears (including RDT&E);
> - The Soviet civilian labor force engaged in defense production has expanded 7.3 percent annually; and
> - The increased share of weapons in defense procurement has caused a modest economy with respect to the labor resources embodied in the total defense procurement.[221]

[220] The original CIA sectoral estimates of Soviet NSE for 1970, which were prepared by Bill Lee as inputs to Steven Rosefielde's draft report (GE 76 TMP-54B), were incorrectly used and have been revised as reflected in Table 3.6.

[221] Op. Cit., Steven Rosefielde, GE-TEMPO draft report (GE 76 TMP-54B), page 13.

Table 3.7 Modified Estimates of the Magnitude and Percentage Composition of Soviet NSE Utilizing the Production Residual Estimation Technique (Commodity Basis) and Excluding RDT&E Expenditures[222]
(billions of 1966 rubles)

1		2	3	4	5	6	7	8	9	10	11	12	13
	Year	1966	1967	1968	1969	1970	1971	1966	1967	1968	1969	1970	197'
	Sector	$d_t^iD_{it}$	$d_t^iD_{it}$	$d_t^iD_{it}$	$d_t^iD_{it}$	$d_t^iD_{it}$	$d_t^iD_{it}$	d_t^i	d_t^i	d_t^i	d_t^i	d_t^i	d_t^i
1	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
2	Fuels	1.3	1.4	1.4	1.5	1.6	1.7	.067	.064	.054	.051	.052	.048
3	Metals	0	0	0	0	0	0	0	0	0	0	0	0
4	Machine-Building	2.5	3.6	4.6	5.75	6.6	7.85	.128	.166	.178	.197	.213	.22
5	Metalworking	5.5	6.2	7.5	9.05	9.4	11.65	.282	.286	.289	.311	.303	.331
6	Construction Materials	0	0	0	0	0	0	0	0	0	0	0	0
7	Chemicals	1.3	1.5	1.7	1.9	2.1	2.3	.067	.069	.066	.065	.068	.065
8	Food	3.20 (2.9)	3.35 (3.0)	3.65 (3.3)	3.80 (3.4)	4.00 (3.6)	4.30 (3.9)	.164 (.149)	.154 (.138)	.141 (.127)	.130 (.117)	.129 (.116)	.12 (.11
9	Light Industry	2.70 (3.0)	2.65 (3.0)	3.05 (3.4)	3.10 (3.5)	3.30 (3.7)	3.40 (3.8)	.138 (.154)	.122 (.138)	.118 (.131)	.106 (.120)	.106 (.119)	.096 (.10
10	Construction	3.0	3.0	4.0	4.0	4.0	4.0	.154	.138	.154	.137	.129	.114
11	Transportation and Communication	0	0	0	0	0	0	0	0	0	0	0	0
12	Trade and Distribution	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	19.5	21.7	25.9	29.1	31.0	35.2	1.000	1.000	1.000	1.000	1.000	1.00

[222] Sources of the data presented in Table 3.7 are as follows:

- Rows 1-3, 6, 7, and 10-12 are identical to the corresponding rows in Table B-7a of Appendix B for Columns 2-7. Columns 8-13 represent the percentage composition of the magnitudes provided in the Total row for Columns 2-7.
- Rows 4 and 5 use the commodity basis estimates in Table 4.7 of Bill Lee's book (i.e., upper-bound values in 1967 prices for Commodity NS durables), where x_{4t}^i represents one-half of these procurement estimates and x_{5t}^i represents the other half plus spare parts which is obtained from Bill Lee's Table D.10 in 1967 prices--after subtracting Sectors 2, 7, and 10 on page 285 of his book.
- Rows 8 and 9 use the estimates of pay and maintenance of Soviet military personnel in Columns 1 and 2 of Bill Lee's Table D.4. The alternative hypotheses with respect to expenditures of wages and social insurance (i.e., 64%/36% and 50%/50%) are applied only to Column 1 of Table D.4 because the entries in Column 2 are always divided between the Food and Light Industry sectors on a 50%/50% basis.

The entries for the Food and Light Industry sectors without parentheses reflect the hypothesis that wages and social insurance are spent 64% on food and 36% on soft goods. On the other hand, the entries with parentheses reflect the hypothesis that wages and social insurance are spent 50% on food and 50% on soft goods.

Table 3.8 Modified Estimates of the Magnitude and Percentage Composition of Soviet NSE Utilizing the Production Residual Estimation Technique (Commodity Basis) and Including RDT&E Expenditures [223]
(billions of 1966 rubles)

1	2	3	4	5	6	7	8	9	10	11	12	13
Year	1966	1967	1968	1969	1970	1971	1966	1967	1968	1969	1970	1971
Sector	$d_t^i D_{it}$	$d_t^i D_{it}$	$d_t^i D_{it}$	$d_t^i D_{it}$	$d_t^i D_{it}$	$d_t^i D_{it}$	d_t^i	d_t^i	d_t^i	d_t^i	d_t^i	d_t^i
1 Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
2 Fuels	1.4	1.5	1.5	1.6	1.7	1.8	.051	.049	.042	.040	.039	.037
3 Metals	0	0	0	0	0	0	0	0	0	0	0	0
4 Machine-Building	7.0	8.6	10.5	11.65	13.7	15.35	.255	.282	.292	.295	.316	.316
5 Metalworking	5.5	6.2	7.5	9.05	9.4	11.65	.200	.203	.208	.229	.216	.240
6 Construction Materials	0	0	0	0	0	0	0	0	0	0	0	0
7 Chemicals	1.5	1.7	1.9	2.2	2.4	2.7	.055	.056	.053	.056	.055	.055
8 Food	3.90 (3.45)	4.10 (3.6)	4.40 (3.9)	4.80 (4.2)	4.75 (4.2)	5.20 (4.6)	.142 (.126)	.134 (.118)	.122 (.108)	.121 (.106)	.109 (.097)	.107 (.095)
9 Light Industry	3.10 (3.55)	3.10 (3.6)	3.50 (4.0)	3.70 (4.3)	3.75 (4.3)	3.90 (4.5)	.113 (.129)	.102 (.118)	.097 (.111)	.094 (.109)	.086 (.099)	.080 (.093)
10 Construction	5.0	5.3	6.7	6.5	7.7	7.9	.182	.174	.186	.164	.177	.163
11 Transportation and Communication	0	0	0	0	0	0	0	0	0	0	0	0
12 Trade and Distribution	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	27.4	30.5	36.0	39.5	43.4	48.5	1.000	1.000	1.000	1.000	1.000	1.000

[223] Sources of data presented in Table 3.8 are as follows:

- Rows 1-3, 6, 7, and 10-12 are identical to the corresponding rows in Table B-7b of Appendix B for Columns 2-7. Columns 8-13 represent the percentage composition of the magnitudes provided in the Total row for Columns 2-7.
- Rows 4 and 5 use the commodity basis procurement estimates from Table 3.7, but the RDT&E material inputs from Column 2 of Table D.16 (page 293) in Bill Lee's book are added to Row 4 after they have been deflated to 1966 prices.
- Rows 8 and 9 use the estimated military RDT&E expenditures from Column 4 of Table D.17 in Bill Lee's book. The alternative hypotheses with respect to the expenditures of wages and social insurance (i.e., 64%/36% and 50%/50%) may be applied to the difference between the estimated RDT&E expenditures and the sum of the RDT&E expenditures for each year in Table A-1 of Appendix A of the GE-TEMPO draft report, GE 76 TMP-54B. This difference, divided in accordance with the foregoing hypotheses between the Food and Light Industry sectors, may then be added to Rows 8 and 9 in Table 3.7.

The entries for the Food and Light Industry sectors without parentheses reflect the hypothesis that wages and social insurance are spent 64% on Food and 36% on soft goods. On the other hand, the entries with parentheses reflect the hypothesis that wages and social insurance are spent 50% on food and 50% on soft goods.

The *feasibility* of Steven Rosefielde's input-output approach has been reinforced by the expanded methodology provided in Appendix B for a generalized burden analysis of Soviet NSE. This statement will be demonstrated by expanding the six tables of data originally provided by Steven Rosefielde to include the following additions, corrections, and changes:

- The value of the Soviet capital stock involved in the production of defense goods has been introduced into the analysis;
- The methodology errors associated with the original sectoral disaggregation of Bill Lee's and the CIA's estimates of Soviet NSE have been corrected;
- The new information reflected in Stanley Cohn's sectoral disaggregation of Soviet NSE greatly alters Steven Rosefielde's original results; and
- The need for a time series sectoral disaggregation of the CIA's estimates of Soviet NSE is evident.

3.6.4 Civilian Manpower Engaged in Soviet Defense Production

Tables 3.9 - 3.13 provide the basis for a preliminary evaluation of the aggregate data used to assess the civilian manpower engaged in Soviet defense production. As may be readily observed, the *magnitude* of the civilian labor force employed in Soviet defense production depends crucially upon the choice of baseline estimation techniques. The basic manpower time *trend* is also influenced by the choice of estimation techniques, as well as by the correction of previous methodology errors on the basis of the set of general disaggregation rules which were developed in this section of the report. Tables 3.9 - 3.13 also provide the basis for an initial evaluation of the aggregate data used to assess the total value and percentage share of the total capital stock utilized in Soviet defense production. It may be readily observed that the *magnitude* and the time *trend* of the Soviet capital resource utilized in Soviet defense production depends crucially upon the choice of baseline estimation techniques. As a consequence, Steven Rosefielde's preliminary conclusions are very sensitive to the estimation technique that is used. Moreover, the need for the development of a time series sectoral disaggregation of the CIA's direct costing estimates of Soviet NSE using the foregoing general

disaggregation rules is clearly evident.

Tables 3.9a and 3.9b provide an expansion of the aggregate burden ratio tables originally presented by Steven Rosefielde with the following explanation:

> Column 1 of both tables presents data on Soviet final demand--classified according to socialist practice as net material product valued in industrial wholesale producers' prices (1966). Commencing in 1966 at a level of 194 billion rubles, Soviet net material product increased at 7.5% annually to 279 billion rubles in 1971. This increase was more rapid than the analogous growth of GNP (as reflected in Tables A-3 and A-6 of Appendix A of the GE-TEMPO draft report), which gives a heavier weight to agriculture, food, and light industrial products valued in retail prices. However, despite this upward NMP bias, Bill Lee's estimates of Soviet NSE (as reflected in Column 5 of Tables 3.9a and 3.9b of this report) grow even more rapidly (i.e., 13.9%) with the result that the defense share of NMP increases from 9.8% in 1966 to 13.1% in 1971, i.e., 6% per annum (as reflected in Column 10 of Table 3.9a of this report). Much of the same observations apply to Table 4 (i.e., Table 3.9b of this report), which presents estimates of Soviet NSE, including military RDT&E. The major difference between Tables 3 and 4 (i.e., Tables 3.9a and 3.9b in this report) is the <u>level</u>, rather than the <u>trend</u>, in defense expenditures. When military RDT&E is included, the defense share of NMP increases by approximately one-third which, by 1971, implies a very high share of 17.4%.[224]

The modified CIA estimates of Soviet NSE for the year 1970 in Column 4 of Tables 3.9a and 3.9b dramatically illustrate the effects of correcting the previous methodology errors by means of the general disaggregation rules in Table 3.5. Bill Lee's modified estimates of Soviet NSE in Column 6 of Tables 3.9a and 3.9b increase almost as rapidly as his original estimates in Column 5 (i.e., 13.4% per year from 1966 to 1971). Consequently, Bill Lee's modified defense share of NMP increases from 10.0% in 1966 to 12.6% in 1971, as reflected in Column 11 of Table 3.9a without military RDT&E expenditures, and increases from 14.1% to 17.4% for the same period, as reflected in Column 11 of Table 3.9b with military RDT&E expenditures. Therefore, even with the foregoing corrections

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[224] Ibid., page 11; underlining and parenthetical references to the various tables in GE-TEMPO draft report (GE 76 TMP-54b) and this summary report have been added for emphasis and clarity, respectively. Inasmuch as military pay is spent directly in the Food and Light Industry sectors, which dominate the Agricultural sector, then the inclusion of military pay in Soviet sectoral NSE should use Soviet GNP, not NNP, for evaluation.

Table 3.9a

The Aggregate Burden of Estimated Soviet NSE by Economic Sectors Without Military RDT&E Expenditures, 1966-1971 [225]
(billions of 1966 rubles)

1	2	3	4	5	6	7	8	9	10	11	12
Year	Total Net Material Product (NMP)	Estimated Soviet NSE					Estimated Aggregate Soviet NSE Burden Ratio				
		Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Cohn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Cohn
1966	194			19.1	19.5	19.85			9.8%	10.0%	10.2%
1967	210			21.8	21.7	21.45			10.4%	10.3%	10.2%
1968	225			26.1	25.9	24.75			11.6%	11.5%	11.0%
1969	238			29.5	29.1	27.05			12.4%	12.2%	11.4%
1970	262	20.5	32.0 to 36.0	31.8	31.0	28.40	7.8%	12.2% to 13.7%	12.1%	11.8%	10.8%
1971	279			36.6	35.2	28.90			13.1%	12.6%	10.3%

Table 3.9b

The Aggregate Burden of Estimated Soviet NSE by Economic Sectors With Military RDT&E Expenditures, 1966-1971 [225]
(billions of 1966 rubles)

1	2	3	4	5	6	7	8	9	10	11	12
Year	Total Net Material Product (NMP)	Estimated Soviet NSE					Estimated Aggregate Soviet NSE Burden Ratio				
		Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Cohn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Cohn
1966	194			25.9	27.4	23.55			13.3%	14.1%	12.1%
1967	210			29.4	30.5	25.35			14.0%	14.5%	12.1%
1968	225			35.0	36.0	28.95			15.5%	16.0%	12.9%
1969	238			38.3	39.5	31.95			16.1%	16.6%	13.4%
1970	262	29.0	40.0 to 45.0	43.0	43.4	34.10	11.0%	15.3% to 17.2%	16.4%	16.5%	13.0%
1971	279			48.5	48.5	34.90			17.4%	17.4%	12.5%

[225] Sources of the data presented in Tables 3.9a and 3.9b are as follows:

- Column 2 data are extracted from Tables 2 and 4 on page 10 of the GE-TEMPO draft report (GE 76 TMP-548) previously cited. The values of NMP are presented in industrial wholesale producers' prices (1966).
- Columns 3 and 5 data are also extracted from Tables 3 and 4 of the GE-TEMPO draft report. The data in Column 5 are also reflected in the Total rows of Tables B-7a and B-7b of Appendix B of this report.
- Column 4 data reflect the low and high estimates in the Column Sum row of Table 3.6.
- Column 6 data are extracted from the Total rows in Tables 3.7 and 3.8, respectively.
- Column 7 data are extracted from the Total rows in Table 88-a and 88-b of Appendix B, respectively.
- Columns 8-12, which are derived by dividing Columns 3-7 by Column 2, respectively, represent Soviet economic burden ratios in terms of NMP. Inasmuch as the values of GNP in 1966 industrial wholesale producer's prices may be obtained by multiplying Column 2 by 1.2, then all of these aggregate NSE burden ratios may be multiplied by .833 so as to be compatible with the normal NSE/GNP burden ratio concept. (i.e., Table A-7 of Appendix A in this summary report) instead of the NSE/NMP concept utilized by Steven Rosefielde.

With reference to the 1970 entries in Columns 3 and 4 of Table 3.9a the modified CIA estimate of 32.0-36.0 billion rubles Column 4 is obtained by adding 1.8 billion rubles for military construction, 3.2 billion rubles for military pay, and 7.3 billion rubles for "missing procurement" to the original CIA estimate of Soviet NSE (without military RDT&E expenditures) in Column 4 (i.e., 20.5 billion rubles). The "missing procurement" error may be traced to a misunderstanding of written correspondence between Bill Lee and Steven Rosefielde on November 4, 1976, as reflected in Footnote 220.

of Bill Lee's original estimates of Soviet NSE by sectors, his modified estimates may still be characterized as requiring an increasing share of Soviet NMP over time. By contrast, Stanley Cohn's estimates of Soviet NSE in Column 7 of Tables 3.9a and 3.9b increase much less rapidly than Bill Lee's modified estimates (i.e., only 7.6% per year from 1966 to 1971). As a result, Stanley Cohn's defense share of NMP remains relatively constant from 1966 to 1971 (i.e., 10.0% to 11.0%, as reflected in Column 12 of Table 3.9a without military RDT&E expenditures), and remains relatively constant at 12.5%, as reflected in Column 12 of Table 3.9b with military RDT&E expenditures. Inasmuch as the general disaggregation rules have been satisfied with Stanley Cohn's estimates of Soviet NSE, then the difference in Bill Lee's estimates reflect possible information errors, rather than methodology errors. Stanley Cohn's estimates of Soviet NSE may therefore be characterized as requiring a constant share of Soviet NMP over time, instead of an increasing share.[226]

Tables 3.10a and 3.10b provide an expansion of the alternative estimates of Soviet civilian manpower engaged in defense production which are explained by Steven Rosefielde as follows:

> Tables 1 and 2 (i.e., Tables 3.10a and 3.10b of this report) reflect the numbers of Soviet civilian manpower involved in the production of defense goods--excluding and including military RDT&E, respectively. Commencing in 1966 with a civilian labor force of 81.1 million workers, it may be observed that, on the basis of Bill Lee's mean estimate of Soviet NSE, 6.6 million workers (as reflected in Column 6 of Table 3.10a of this report) were employed in Soviet defense production. This implies that the defense share of the total civilian work force was 8.2% (as reflected by the figures without parentheses in Table 3.10a of this report)....
>
> During the period 1966-1971, it would appear that civilian employment in the Soviet defense production sector rose at a compound annual rate of 7.3%--i.e., from 6.6 to 9.4 million workers (as reflected in Column 6 of Table 3.10a of this report). This rate of increase directly reflects Bill Lee's estimate of the growth in the production sector of Soviet NSE, excluding military RDT&E, of 13.9% per annum. The difference between the two rates may be explained in terms of increased factor productivity. However, these growth rates appear to be somewhat high and may require some further consideration.

[226] This general distinction between increasing or constant share of Soviet NMP or GNP may be used to characterize all of the baseline estimation methodologies.

Table 3.10a

Alternative Estimates of the Soviet Civilian Manpower Engaged in Defense Production by Economic Sectors Without Military RDT&E Expenditures, 1966-1971 [227]

1	2	3	4	5	6	7	8	9	10	11	12	13
Year	Total Civilian Work Force (millions)	Civilian Work Force Employed in 12 Sectors (millions)	Alternative Estimates of Soviet Civilian Manpower Defense Production (millions)					Alternative Estimates of Soviet Aggregate Burden Ratio for the Labor Resource				
			Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966	81.1 (79.7)	55.8			6.6	7.0	6.8			8.2% (11.8%)	8.6% (12.5%)	8.4% (12.2%)
1967	82.7 (82.3)	57.5			7.0	7.3	6.9			8.5% (12.2%)	8.8% (12.7%)	8.3% (12.0%)
1968	84.8 (85.1)	59.3			8.0	8.3	7.6			9.5% (13.5%)	9.8% (14.0%)	8.9% (12.8%)
1969	86.9 (87.9)	61.2			8.6	9.0	8.1			9.9% (14.1%)	10.3% (14.7%)	9.3% (13.2%)
1970	90.0 (90.2)	62.7	5.7	9.9 to 10.9	8.7	9.0	8.0	6.3% (9.1%)	11.% to 12.% (15.8% to 17.4%)	9.7% (13.9%)	10.0% (14.3%)	8.9% (12.7%)
1971	92.4 (92.8)	64.5			9.4	9.5	7.8			10.2% (14.6%)	10.3% (14.7%)	8.4% (12.1%)

Table 3.10b

Alternative Estimates of the Soviet Civilian Manpower Engaged in Defense Production by Economic Sector With Military RDT&E Expenditures, 1966-1971 [227]

1	2	3	4	5	6	7	8	9	10	11	12	13
Year	Total Civilian Work Force (millions)	Civilian Work Force Employed in 12 Sectors (millions)	Alternative Estimates of Soviet Civilian Manpower in Defense Production (millions)					Alternative Estimates of Soviet Aggregate Burden Ratio for the Labor Resource				
			Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966	81.1 (79.7)	55.8			8.9	9.8	8.2			11.0% (15.9%)	12.1% (17.6%)	10.1% (14.7%)
1967	82.7 (82.3)	57.5			9.5	10.2	8.4			11.4% (16.5%)	12.3% (17.7%)	10.2% (14.6%)
1968	84.8 (85.1)	59.3			10.8	11.5	9.1			12.7% (18.2%)	13.6% (19.4%)	10.7% (15.3%)
1969	86.9 (87.9)	61.2			11.1	12.2	9.9			12.8% (18.1%)	14.0% (19.9%)	11.4% (16.2%)
1970	90.0 (90.2)	62.7	8.1	12.5 to 14.0	11.9	12.6	9.8	9.1% (12.9%)	13.9% to 15.5% (19.9% to 22.3%)	13.2% (19.0%)	14.0% (20.1%)	10.9% (15.6%)
1971	92.4 (92.8)	64.5			12.6	13.2	9.7			13.6% (19.5%)	14.3% (20.6%)	10.5% (15.0%)

[227] Sources of the data presented in Tables 3.10a and 3.10b are as follows:

- Column 2 data without parentheses are extracted from Tables 1 and 2 on page 9 of the GE-TEMPO draft report (GE 76 TMP-54B) previously cited. The data in parentheses are extracted from Tables 11 and 12 on pages 136-137 of the previously cited paper by Murray Feshbach and Stephen Rapawy on "Soviet Population and Manpower Trends and Policies," in the JEC report on the Soviet Economy in a New Perspective, October 14, 1976.
- Column 3 data reflect the Total row in Table B-2 of Appendix B.
- Columns 4, 6, 9 and 11 data without parentheses are extracted from Tables 1 and 2 on page 8 of the GE-TEMPO draft report (GE 76 TMP-54B) previously cited.
- Column 5 data are derived by using Column 2, 3, 6 and 7 data from Table 3.6 in Equation (B-14) of Appendix B and summing over all of the 12 economic sectors (i.e., $e'L_t^{10}$).
- Column 7 data are derived by using the data in Tables 3.7 and 3.8 in Equation (B-14) of Appendix B and summing over all of the 12 economic sectors (i.e., $e'L_t^{8}$).
- Column 8 data are derived by using the data in Tables B-8a and B-8b in Equation (B-14) of Appendix B and summing over all of the 12 economic sectors (i.e., $e'L_t^{9}$).
- Column 9 data with parentheses are derived by dividing Column 5 by Column 3.
- Column 10 data without parentheses are derived by dividing Column 5 by Column 2 without parentheses. Column 10 data with parentheses are derived by dividing Column 5 by Column 3.
- Column 11 data with parentheses are derived by dividing Column 6 by Column 3.
- Column 12 data without and with parentheses are derived by dividing Column 7 by Column 2 without parentheses and Column 3, respectively.
- Column 13 data without and with parentheses are derived by dividing Column 8 by Column 2 without parentheses and Column 3, respectively.

> Table 2 (i.e., Table 3.10b of this report) presents a similar estimate, but military RDT&E is included. The estimate of civilian manpower engaged in defense production in 1966, based upon Bill Lee's estimate of Soviet NSE, is 8.9 million, which is approximately 11% of the total civilian work force... As was the case with figures presented in Table 1 (i.e., Table 3.10a of this report), it would appear that the civilian employment in the Soviet defense production sector rose at a rate of slightly more than 7% per annum (i.e., 7.2%) between 1966 and 1971, while growth in the production sector of Soviet NSE was in excess of 13% (i.e., 13.4%). Thus, although the level of both Soviet NSE and civilian manpower engaged in defense production is substantially higher when military RDT&E is included, the time profile is fundamentally the same.[228]

The modified CIA estimates of Soviet civilian manpower engaged in defense production in Column 5 of Tables 3.10a and 3.10b are substantially higher than the original CIA estimates utilized by Steven Rosefielde--which dramatically reflects the correction of previous methodology errors by means of the general disaggregation rules summarized in Table 3.5. Bill Lee's modified estimate of Soviet civilian manpower involved in the production of defense goods increases almost as rapidly as his original estimates in Column 6 of Tables 3.10a and 3.10b. During the period 1966-1971, the rate of increase (excluding military RDT&E expenditures) is 6.0%, as reflected in Column 7 of Table 3.10a, whereas the rate of increase (including military RDT&E expenditures) is 5.8%, as reflected in Column 7 of Table 3.10b. The percentage share of the total civilian work force involved in defense production increased from 8.6% in 1966 to 14.7% in 1971, as reflected in Column 12 of Table 3.10a without military RDT&E expenditures, and increased from 12.1% to 14.3% for the same period, as reflected in Column 12 of Table 3.10b with military RDT&E expenditures.

The aggregate burden percentages shown in parentheses in Columns 9-13 of Tables 3.10a and 3.10b reflect the estimated percentage share of the civilian work force employed in the 12 economic sectors previously defined instead of the total civilian work force. The difference between the totals for the civilian work force in Columns 2 and 3 of Tables 3.10a and 3.10b generally reflects the exclusion of civilian employment in the service sectors (e.g., Health Services, Government Administration, and Education and Culture).[229]

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[228] Op. Cit., GE-TEMPO draft report (GE 76 TMP-54B), page 9; underlining and parenthetical references to Tables 3.10a and 3.10b of this report have been added for emphasis and clarity, respectively.

[229] Op. Cit., Murray Feshbach and Stepen Rapawy, "Soviet Population and Manpower Trends and Policies," Tables 11 and 12, pages 136-137.

Therefore, the aggregate burden percentages shown without parentheses in Columns 9-13 of Tables 3.10a and 3.10b reflect the percentage share of the total civilian work force producing all of the goods and services that are involved in the production of defense goods. By contrast, the aggregate burden percentages shown with parentheses reflect only the percentage share of the total civilian work force producing all of the goods that are involved in the production of defense goods.[230]

Bill Lee's original and modified estimates of the aggregate burden ratios for the labor resource in Columns 11 and 12 of Tables 3.10a and 3.10b (both with or without parentheses) may be characterized as requiring an increasing share of the Soviet civilian labor force over time. Correction of the original methodology errors influences primarily the disaggregation of the aggregate labor resource burden ratios over the 12 economic sectors because the total percentages in Columns 11 and 12 of Tables 3.10a and 3.10b are in relatively close agreement. By contrast, Stanley Cohn's estimate of the Soviet civilian manpower involved in the production of defense goods increases much less rapidly than Bill Lee's original or modified estimates in Tables 3.10a and 3.10b. For period 1966-1971, the rate of increase estimated by Stanley Cohn is 2.5%, excluding military RDT&E expenditures (as reflected in Column 8 of Table 3.10a), and 3.0%, including military RDT&E expenditures (as reflected in Column 8 of Table 3.10b). As may also be observed in Column 13 of Table 3.10a (i.e., without military RDT&E expenditures), the percentage share of the total civilian work force involved in defense production remains relatively constant at 8.4% from 1966-1971. Similarly, it may be observed in Column 13 of Table 3.10b (i.e., with military RDT&E expenditures) that the percentage share for the same period remains relatively constant at 10.0-11.0%. Therefore, Stanley Cohn's estimated aggregate burden ratios in Column 13 of Tables 3.10a and 3.10b (i.e., with and without parentheses) may be characterized as requiring only a constant share of the Soviet civilian labor force over time. In this context, the estimated factor productivity associated with the Stanley Cohn's growth rate in light of the differences between the increases in estimated Soviet NSE in Tables 3.9a and

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[230] The total civilian work force shown in parentheses in Column 2 of Tables 3.10a and 3.10b excludes the work force in collective farms. These totals therefore agree with those presented by Murray Feshbach and Steve Rapawy in their previously cited paper.

3.9b and the increase in estimated Soviet defense-related employment in Tables 3.10a and 3.10b is lower than the estimated factor productivity cited by Steven Rosefielde on page 181. The three alternative estimates of factor productivity associated with the Labor Resource are:

- Bill Lee's original estimate (without RDT&E) = (13.9%-7.3%) = 6.6% and (with RDT&E) = (14.5%-6.9%) = 7.6% .
- Bill Lee's modified estimate (without RDT&E) = (13.4%-6.0%) = 7.4% and (with RDT&E) = (12.8%-5.8%) = 7.0% .
- Stanley Cohn's estimate (without RDT&E) = (7.6%-2.5%) = 5.1% and (with RDT&E) = (8.0%-3.0%) = 5.0% .

It is readily apparent that Stanley Cohn's estimates of factor productivity are lower and therefore appear to be more credible.

Tables 3.11a and 3.11b provide alternative estimates of the value of the total Soviet capital stock involved in Soviet defense production. As may be observed in Column 2 of both tables, estimates of the value of the capital resources (both fixed and working capital) actually utilized in the 12 economic sectors previously defined are provided over time in 1966 rubles. It may also be determined from the values in Column 2 that the average rate of growth in the value of this capital stock from 1966 to 1971 is 8.3 percent (i.e., from 499.0 billion rubles to 748.5 billion rubles). The actual alternative estimates of the value of the Soviet capital stock involved in the production of defense goods excluding military RDT&E, are presented in Columns 3-7 of Table 3.11a. As may be observed in Columns 3, the original CIA estimate of Soviet capital stock engaged in defense production in 1970 is substantially less than the modified CIA estimate shown in Column 4--which is the result of the correction of the original methodology errors by means of the general disaggregation rules in Table 3.5. Insofar as Bill Lee's estimates of the level of Soviet capital resources involved in defense production are concerned, the indicated rate of growth is 16.8 percent (i.e., from 31.3 billion rubles in 1966 to 62.8 billion in 1971). This very rapid rate of growth implies that the defense share of the aggregate capital stock is increased from 6.3 to 8.4 percent during the period 1966-1971 as indicated in Column 10 of Table 3.11a. This characteristic (i.e., an increasing capital resource burden ratio over time) is common to both the original and modified estimates of Bill Lee. Although Bill Lee's modified

Table 3.11a

Alternative Estimates of the Total Soviet Capital Stock Engaged in Defense Production by Economic Sectors Without Military RDT&E Expenditures, 1966-1971 [231]

1	2	3	4	5	6	7	8	9	10	11	12
Year	Capital Stock Utilized in 12 Sectors (billions of 1966 rubles)	Alternative Estimates of Soviet Capital Stock Used in Defense Production (billions of 1966 rubles)					Alternative Estimates of the Soviet Aggregate Burden Ratio for the Capital Resource				
		Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966	499.0			31.3	31.8	33.8			(6.3%)	(6.4%)	(6.8%)
1967	539.3			36.2	35.9	37.2			(6.7%)	(6.6%)	(6.9%)
1968	582.7			42.8	42.4	44.1			(7.3%)	(7.2%)	(7.6%)
1969	625.8			49.4	48.9	49.2			(7.9%)	(7.8%)	(7.9%)
1970	688.9	35.1	51.8 to 59.5	53.8	52.6	51.6	(5.1%)	(7.5% to 8.6%)	(7.8%)	(7.6%)	(7.5%)
1971	748.5			62.8	60.8	53.4			(8.4%)	(8.1%)	(7.1%)

Table 3.11b

Alternative Estimates of the Total Soviet Capital Stock Engaged in Defense Production by Economic Sectors With Military RDT&E Expenditures, 1966-1971 [231]

1	2	3	4	5	6	7	8	9	10	11	12
Year	Capital Stock Utilized in 12 Sectors (billions of 1966 rubles)	Alternative Estimates of Soviet Capital Stock Used in Defense Production (billions of 1966 rubles)					Alternative Estimates of the Soviet Aggregate Burden Ratio for the Capital Resource				
		Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966	499.0			40.7	42.7	40.3			(8.1%)	(8.6%)	(8.1%)
1967	539.3			46.7	48.1	44.0			(8.7%)	(8.9%)	(8.2%)
1968	582.7			54.9	56.2	52.0			(9.4%)	(9.6%)	(8.9%)
1969	625.8			61.7	63.6	58.5			(9.9%)	(10.2%)	(9.3%)
1970	688.9	48.0	63.0 to 72.4	69.4	70.0	62.6	(7.0%)	(9.1% to 10.5%)	(10.1%)	(10.2%)	(9.1%)
1971	748.5			79.4	79.8	65.5			(10.6%)	(10.7%)	(8.7%)

[231] Sources of the data presented in Tables 3.11a and 3.11b are as follows:

- Column 2 data reflect the Total row in Table B-5 of Appendix B.
- Column 3 is derived by using the data in Table A-2, Appendix A of GE-TEMPO report (GE 76 TMP-548) as the $d_t^{10}D_{it}$ term in Equation (B-15) of Appendix B of this summary report and summing over the 12 economic sectors (i.e., $e'\hat{K}_t^{10}$).
- Column 4 is derived by using the data in Columns 2, 3, 6 and 7 of Table 3.6 in Equation (B-15) of Appendix B and summing over the 12 economic sectors (i.e., $e'\hat{K}_t^{10}$).
- Column 5 is derived by using the data in Tables B-7a and B-7b of Appendix B in Equation (B-15) of the same appendix and summing over the 12 economic sectors (i.e., $e'\hat{K}_t^{8}$).
- Column 6 is derived by using the data in Tables 3.7 and 3.8 in Equation (B-15) of Appendix B and summing over the 12 economic sectors (i.e., $e'\hat{K}_t^{8}$).
- Column 7 is derived by using the data in Tables B-8a and B-8b of Appendix B in Equation (B-15) of the same appendix and summing over the 12 economic sectors (i.e., $e'\hat{K}_t^{6}$).
- Column 8 is Column 3 divided by Column 2.
- Column 9 is Column 4 divided by Column 2.
- Column 10 is Column 5 divided by Column 2.
- Column 11 is Column 6 divided by Column 2.
- Column 12 is Column 7 divided by Column 2.

The aggregate burden ratio for the capital resource is determined as a percentage of all the capital stock utilized in the 12 economic sectors previously identified. However, inasmuch as this does not represent the total capital stock available for the Soviet economy, then the burden ratios shown in parentheses in Columns 8-12 indicate that they are higher than their true magnitudes, but the indicated time trends are still valid.

growth rate of 15.2 percent for the period 1966-1971 (i.e., from 31.8 billion rubles in 1966 to 60.8 billion rubles in 1971, as reflected in Column 6) is slightly less than his original growth rate, the defense share of the aggregate capital stock still increases from 6.4 to 8.1 percent as indicated in Column 11 of Table 3.11a. By contrast, Stanley Cohn's estimate of the value of Soviet capital stock involved in the production of defense goods increases at the rate of only 9.7 percent per year--which is considerably less than Bill Lee's original or modified estimates (i.e., 16.8% and 15.2%, respectively). As a result, Stanley Cohn's aggregate burden ratio in Column 12 of Table 3.11a remains relatively stable at 7 percent from 1966 to 1971.

Table 3.11b presents a similar pattern of Soviet capital resource burden ratios over time for the various alternative estimation techniques, but now the military RDT&E expenditures are included. The rates of growth for Bill Lee's original and modified estimates of Soviet capital stock utilized in defense production, as well as Stanley Cohn's estimates, are 15.8%, 14.5%, and 10.4%, respectively, based upon the data in Columns 5, 6, and 7 of Table 3.11b. In the case of Bill Lee's estimates, the average annual rates of growth are slightly lower with military RDT&E expenditures included than without military RDT&E, whereas Stanley Cohn's rate of growth with military RDT&E expenditures is slightly higher than without military RDT&E expenditures. This difference between Bill Lee's and Stanley Cohn's estimates reflects the different sectoral composition that is associated with Bill Lee's estimates of Soviet military RDT&E by comparison with those of Stanley Cohn. Another significant contrast between Bill Lee's and Stanley Cohn's estimates is that Bill Lee's estimates of the aggregate burden ratios for the capital resource in Columns 10 and 11 of Table 3.11b may be characterized as requiring an increasing share of the capital stock over time while Stanley Cohn's estimates of the aggregate burden ratios in Column 12 may be characterized as requiring only a constant share of the capital resource for the period 1966-1971.

Tables 3.12a and 3.12b reflect the structure of Soviet civilian manpower engaged in defense production and the associated capital resource requirements which Steven Rosefielde explains as follows:

> As may be observed, the table (i.e., Table 5 in the GE-TEMPO draft report previously cited, but Table 3.12a of this report) presents data on the ratio of defense employment and output shares derived from Tables 1-4 (i.e., Tables 3.9a, 3.9b, 3.10a and 3.11b of this report). Each statistic measures whether Soviet civilian manpower employed in defense production constitutes a greater or smaller share of the total civilian labor force than the analogous defense expenditure share of NMP. As is readily apparent, defense procurement is relatively less labor-intensive than the economywide average; i.e., approximately .8 (i.e., the entries without parentheses in Table 3.12a). This is not really surprising in view of the extreme labor intensity of Soviet agriculture. However, the trend is more interesting in moving from .84 to .78; that is, declining at a rate of 1.5% per annum (as reflected in Column 4 of Table 3.12a). This behavior is largely explained by the increasing share of weapons in the total Soviet defense procurement. Since the labor/GVO ratio in machine building is less than the average for the other sectors wherein military procurement is important, its increased weight in the total has caused a gradual reduction in civilian defense manpower requirements. Had the ratio (i.e., .84) prevailing in 1966 still been in force in 1971 (i.e., instead of .78), civilian defense workers would have increased by another 7.7%.[232]

A number of Steven Rosefielde's observations with regard to the structure of Soviet civilian manpower engaged in defense production are crucially dependent upon the choice of estimation technique and upon some very special assumptions which have been made.

For example,

- *Defense procurement* is "relatively less labor-intensive than the economy-wide average" only when civilian employment in the service sectors is included. However, if civilian employment in the service sectors is excluded, then the figures in parentheses in Table 3.12a all exceed unity, which would imply that defense procurement is "relatively more labor-intensive than the economy-wide average". Clearly, this reversal in the relative labor-intensiveness of defense procurement has nothing at all to do with the "extreme labor-intensity of Soviet agriculture". Instead, it depends upon the definition of the aggregate burden ratio for the labor resource actually

[232] Op. Cit., GE-TEMPO draft report (GE 76 TMP-54B), page 11; underlining and parenthetical references to the various tables in the GE-TEMPO draft report and this summary report have been added for emphasis and clarity, respectively.

Table 3.12a

Alternative Estimates of the Ratio of the Percentage of Soviet Civilian Workers Employed in Defense Production to the Defense Expenditure Shares of Soviet Net Material Product (1966 to 1971) [233]

1	2	3	4	5	6	7	8	9	10	11
Year	Alternative Estimates of Soviet Defense Employment/Output Shares, Excluding Military RDT&E					Alternative Estimates of Soviet Defense Employment/Output Shares, Including Military RDT&E				
	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966			.84 (1.20)	.86 (1.25)	.82 (1.20)			.83 (1.19)	.86 (1.25)	.83 (1.21)
1967			.82 (1.17)	.85 (1.23)	.81 (1.18)			.81 (1.18)	.85 (1.22)	.84 (1.21)
1968			.82 (1.16)	.85 (1.22)	.81 (1.16)			.82 (1.17)	.85 (1.21)	.83 (1.19)
1969			.80 (1.14)	.84 (1.20)	.82 (1.16)			.80 (1.12)	.84 (1.20)	.85 (1.21)
1970	.80 (1.17)	.90 to .88 (1.15 to 1.27)	.80 (1.14)	.84 (1.21)	.82 (1.18)	.83 (1.17)	.91 to .90 (1.30 to 1.27)	.80 (1.16)	.85 (1.22)	.84 (1.20)
1971			.78 (1.11)	.82 (1.17)	.82 (1.17)			.78 (1.12)	.82 (1.18)	.84 (1.20)

Table 3.12b

Alternative Estimates of the Ratio of the Percentage of Total Soviet Capital Stock Utilized in Defense Production to the Defense Expenditure Shares of Soviet Net Material Product (1966 to 1971) 233

1	2	3	4	5	6	7	8	9	10	11
Year	Alternative Estimates of the Soviet Defense Utilization of Capital Stock/Output Shares, Excluding Military RDT&E					Alternative Estimates of the Soviet Defense Utilization of Capital Stock/Output Shares, Including Military RDT&E				
	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966			(.64)	(.64)	(.67)			(.61)	(.61)	(.67)
1967			(.64)	(.64)	(.68)			(.62)	(.61)	(.68)
1968			(.63)	(.63)	(.69)			(.61)	(.60)	(.69)
1969			(.64)	(.64)	(.69)			(.61)	(.61)	(.69)
1970	(.65)	(.61 to .63)	(.64)	(.64)	(.69)	(.64)	(.59 to .61)	(.62)	(.62)	(.70)
1971			(.64)	(.64)	(.69)			(.61)	(.61)	(.70)

233 The sources of the data presented in Tables 3.12a and 3.12b are as follows:

- Data in Columns 2-6 of Table 3.12a are derived by dividing the data in Columns 9-13 of Table 3.10a by Columns 8-12 of Table 3.9a in turn.
- Data in Columns 7-11 of Table 3.12a are derived by dividing the data in Columns 9-13 of Table 3.10b by Columns 8-12 of Table 3.9b in turn.
- Data in Columns 2-6 of Table 3.12b are derived by dividing the data in Columns 9-13 of Table 3.11a by Columns 8-12 of Table 3.9a in turn.
- Data in Columns 7-11 of Table 3.12b are derived by dividing the data in Columns 9-13 of Table 3.11b by Columns 8-12 of Table 3.9b in turn.

It should be noted that each entry in Table 3.12a was computed as the ratio of:

$$\left(\frac{\text{Defense employment/total civilian employment}}{\text{Defense expenditures/total net material product}}\right)$$

On the other hand, each entry in Table 3.12b was computed as the ratio of:

$$\left(\frac{\text{Defense utilization of capital stock/total utilization of capital stock}}{\text{Defense expenditures/total net material product}}\right)$$

The entries in parentheses in Tables 3.12a and 3.12b reflect the replacement of:

- "Total civilian employment" in the denominator with "civilian work force employed in 12 sectors" in Table 3.12a; and
- "Total capital stock utilized" in the denominator with the "capital stock utilized in 12 sectors" in Table 3.12b.

used in Tables 3.10a and 3.10b.[234]

- The <u>magnitude</u> of the ratio of defense employment to defense production shares is very sensitive to the correction of previous methodology errors by means of the general disaggregation rules in Table 3.5. This may be readily observed by comparing the original and modified CIA estimates for 1970 in Columns 2 and 3, as well as in Columns 7 and 8, of Table 3.12a.

- The <u>trend</u> with respect to the ratio of defense employment to defense production shares is very sensitive to the selection of the estimation technique, as well as to the general disaggregation rules in Table 3.5. A comparison of Bill Lee's original estimates of the ratios in Columns 4 and 9 with Stanley Cohn's estimates in Columns 6 and 11 of Table 3.12a indicates that the foregoing trend is entirely eliminated (i.e., a <u>zero</u> trend) when one shifts from Bill Lee's to Stanley Cohn's estimation technique. A comparison of Bill Lee's original estimates with his modified estimates of the ratios in Columns 5 and 10 of Table 3.12a indicates that application of the general disaggregation rules in Table 3.5 substantially <u>weakens</u> the foregoing trend (i.e., instead of progressing from .84 to .78, the modified trend progresses from .86 to .82, which reflects a rate of only 0.8% per annum). Clearly, this weakening or complete elimination of the trend indicated in Columns 5 and 10 or Columns 6 and 11 of Table 3.12a has nothing to do with "the increasing share of weapons in the total Soviet defense procurement" as originally postulated by Steven Rosefielde. Therefore, the <u>structure</u> of Soviet requirements for civilian manpower in defense production over time can be more fully evaluated only after a time series sectoral disaggregation of the CIA estimates of Soviet defense spending is obtained or developed as previously cited. This disaggregation would make possible the completion of Columns 3 and 8 of Table 3.12a and would provide another much needed set of estimates with respect to the <u>magnitude</u> and <u>trend</u> of the ratio of defense employment to defense production shares.

- Table 3.12b reflects the structure of Soviet capital stock requirements for defense production over time. As may be noted, the ratio of capital utilization for defense to defense production shares is derived from Tables 3.9a, 3.9b, 3.11a, and 3.11b. In this context, each entry in Table 3.12b measures whether the Soviet capital stock employed in defense production constitutes a greater or smaller share of the total capital resource employed in the 12 sectors previously defined than the analogous defense expenditure

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[234] The civilian work force engaged in Soviet agriculture is included in <u>both</u> definitions. The total civilian work force that produces all goods and services is reflected in the figures without parentheses in Figure 3.12a, and the civilian work force that produces only goods is reflected in the figures with parentheses.

share of NMP. Although all of the ratios are less than unity in Table 3.12b (i.e., about two-thirds), this does not suggest that "defense procurement is relatively less capital-intensive than the economy-wide average". It simply indicates that the Soviet aggregate burden ratio for the capital resource is less than the Soviet aggregate burden ratio for the share of NMP to Soviet NSE.[235]

- In addition, the modified CIA estimates in Columns 3 and 8 of Table 3.12b are actually less than the original CIA estimates in Columns 2 and 7, respectively--which is opposite the result in Table 3.12a for the labor resource when the previous methodology errors are corrected by means of the general disaggregation rules in Table 3.5. Moreover, Bill Lee's original and modified estimates in Columns 4, 5, 9, and 10 of Table 3.12b reflect no perceptible trend in the ratio over time. However, Stanley Cohn's estimates in Columns 6 and 11 do reveal a slight trend in terms of the ratio moving from .67 to .69 or .70 during the period 1966-1971 (i.e., increasing at a rate of 0.75% per annum). This may be explained by the presence of an increasing share of weapons in the total estimated Soviet NSE. However, this explanation would be more appropriate for Bill Lee's estimates, if a trend could be detected in his estimates--but none is observable in Table 3.12b during the period 1966-1971. Once again, it is therefore very important to obtain or develop a time series sectoral disaggregation of the CIA estimates of Soviet NSE in order to more fully evaluate the structure of the Soviet capital stock requirements for defense production over time. This disaggregation would make possible the completion of Columns 3 and 8 of Table 3.12b and would provide another much needed set of estimates of the magnitude and the trend in the ratio of capital stock utilization for defense and defense production.

- Finally, the time period under consideration should be expanded to cover the entire period of 1960-1975.

The structure of the Soviet labor and capital resources required to sustain Soviet defense production may be more easily evaluated by a sectoral disaggregation of the total resource requirements for Soviet defense output--which is explained by Steven Rosefielde as follows:

> The structural transformation in the sectoral composition of the Soviet civilian manpower engaged in defense production is illustrated still more clearly in Table 6 (i.e., Table 3.13a of this report), which provides data on the manpower contribution of machine-building to total civilian defense manpower. Columns

[235] Each entry in Tables 3.12a and 3.12b represents the ratio of two "burden ratios". Since Soviet GNP is roughly equal to 1.2 times Soviet NMP, then each entry in these tables would be 20% higher, if the usual Soviet aggregate burden ratio for the share of GNP to Soviet NSE is used.

Table 3.13a

Alternative Estimates of the Machine-Building and Metalworking Composite Sector Percentage Share of the Total Civilian Manpower Engaged in Soviet Defense Production (1966-1971) [236]

1	2	3	4	5	6	7	8	9	10	11
	Excluding Military RDT&E Expenditures					Including Military RDT&E Expenditures				
Year	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966			31.5% (31.8%)	25.4% (25.6%)	25.5% (25.8%)			34.4%	28.1% (28.3%)	22.4% (22.5%)
1967			34.3% (34.2%)	27.6% (27.7%)	25.7% (26.0%)			35.9%	29.5% (29.7%)	22.2% (22.5%)
1968			34.1% (34.4%)	27.7% (27.9%)	25.5% (25.8%)			35.1% (35.9%)	29.6% (29.8%)	22.2% (22.6%)
1969			35.1% (35.0%)	28.8% (29.0%)	24.7% (25.0%)			36.1%	29.6% (29.8%)	21.2% (21.5%)
1970	32.0% (38.9%)	35.6% to 33.9%	36.2%	29.5% (29.7%)	25.7% (26.0%)	39.0% (37.6%)	32.9% to 31.2%	36.3%	30.3% (30.5%)	21.9% (22.2%)
1971			37.6% (37.3%)	30.5% (30.7%)	25.4% (25.7%)			37.1%	30.5% (30.7%)	20.7% (21.1%)

Table 3.13b

Alternative Estimates of the Machine-Building and Metalworking Composite Sector Percentage Share of the Total Capital Stock Utilized in Soviet Defense Production (1966-1971) [236]

1	2	3	4	5	6	7	8	9	10	11
	Excluding Military RDT&E Expenditures					Including Military RDT&E Expenditures				
Year	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn	Original CIA	Modified CIA	Original Lee	Modified Lee	Stanley Conn
1966			24.4%	20.5% (20.5%)	18.0% (18.0%)			27.0%	23.1% (23.1%)	15.8% (15.8%)
1967			25.8%	21.8% (21.9%)	17.9% (18.0%)			27.9%	24.1% (24.1%)	15.8% (15.8%)
1968			25.8%	21.9% (21.9%)	17.0% (17.0%)			27.7%	23.9% (24.0%)	15.1% (15.1%)
1969			25.6%	22.1% (22.1%)	16.3% (16.4%)			27.0%	23.3% (23.3%)	14.3% (14.4%)
1970	26.4%	27.4% to 25.7%	25.8%	22.1% (22.1%)	16.9% (16.9%)	27.2%	26.2% to 24.6%	27.0%	23.6% (23.6%)	14.6% (14.7%)
1971			26.2%	22.5% (22.6%)	16.7% (16.7%)			27.0%	23.5% (23.5%)	14.0% (14.0%)

[236] Sources of the data presented in Tables 3.13a and 3.13b are as follows:

- Columns 2, 4, and 9 entries in Table 3.13a without parentheses are derived from Table 6, page 12 of GE-TEMPO draft report (GE 76 TMP-54B), while those entries with parentheses are simply recalculations based upon Equation (B-14) in Appendix B (i.e., the MBMW percentage share of $e^{*}L_t^{10}$). On the other hand, Column 2, 4, and 9 entries in Table 3.13b are calculated by using the data which are presented in:
  - Table A-2 of Appendix A in the foregoing GE-TEMPO report as $d_t^{10}{}_{it}$ in Equation (B-15) of Appendix B of this summary report, and
  - Tables B-7a and B-7b in Equation (B-15) of Appendix B (i.e., the MBMW percentage share of $e^{*}K_t^{10}$).
- Columns 3 and 8 of Table 3.13a are calculated by using Columns 2, 3, 6, and 7 of Table 3.16 in Equation (B-14) of Appendix B. Moreover, Columns 3 and 8 of Table 3.13b use the same data in Equation (B-15) of Appendix B (i.e., the MBMW percentage share of $e^{*}L_t^{10}$ and $e^{*}K_t^{10}$, respectively).
- Columns 5 and 10 of Tables 3.13a and 3.13b are calculated by using the data presented in Tables 3.7 and 3.8 in Equations (B-14) and (B-15), respectively, of Appendix B (i.e., the MBMW percentage share of $e^{*}L_t^{9}$ and $e^{*}K_t^{9}$, respectively). The entries without parentheses in these columns reflect the 64% & 36% hypothesis with respect to the consumption pattern, while those entries with parentheses reflect the 50% & 50% hypothesis.
- Columns 6 and 11 of Tables 3.13a and 3.13b are calculated by using the data presented in Tables B-8a and B-8b in Equations (B-14) and (B-15), respectively, of Appendix B (i.e., the MBMW percentage share of $e^{*}L_t^{9}$ and $e^{*}K_t^{9}$, respectively). The entries without parentheses reflect the 64% & 36% hypothesis with respect to the consumption pattern, while those entries with parentheses reflect the 50% & 50% hypothesis.

> 2 and 4 are computed from Soviet defense expenditures excluding RDT&E, while Columns 7 and 9 are computed including RDT&E. In 1970, which is considered to be the most reliable observation, 36.2% of this civilian labor involved in final defense procurements was specifically embodied in the final outputs of machine-building; that is, military weapons, irrespective of whether or not RDT&E is included or excluded. From 1966, when this figure was 31.5%, the weapons share increased at 3.6% per annum to 37.6% in 1971, excluding RDT&E, and at half that rate including RDT&E (i.e., based on the original Lee estimates). Ceteris paribus, if the structural trends are reasonably accurate, <u>it can be deduced that augmenting the hardware component of Soviet defense procurement results in a modest economy with respect to scarce labor resources as compared with alternative ways in which defense expenditures might be allocated to competing defense uses</u>.[237]

Bill Lee's modified estimates in Column 5 of Table 3.13a which excludes military RDT&E indicate a much <u>lower</u> percentage for each year than his original estimates in Column 4 as cited by Steven Rosefielde--which is a dramatic reflection of the correction of the previous methodology errors by means of the general disaggregation rules in Table 3.5. However, the increasing trend during the period 1966-1971 still remains in Bill Lee's modified estimates in Columns 5 and 10 of Table 3.13a. Only when another baseline estimation methodology is utilized is this <u>increasing</u> trend eliminated--which is clearly evident in Stanley Cohn's estimates in Columns 6 and 11 of Table 3.13a. In fact, the entries in Column 11 reflect a slightly <u>decreasing</u> trend in Stanley Cohn's estimates, which include military RDT&E. Therefore, the MBMW sectoral structural trend is very sensitive to the selection of the estimating technique, and indicates a need for additional research before Steven Rosefielde's preliminary conclusion, which was underlined in the foregoing citation, may be substantiated.[238]

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[237] Op. Cit., GE-TEMPO draft report (GE 76 TMP-54B), page 13; underlining and the parenthetical reference to Table 3.13a in this report have been added for emphasis and clarity, respectively.

[238] Although the modified Lee and Stanley Cohn estimates provide opposite findings (which demonstrate the importance of carefully analyzing these alternative baseline methodologies), the conclusions in this section of the report are considered to be "conditionally valid"--given the general ranking of the estimating techniques in Section 2.0 of this report.

Table 3.13b provides data with regard to the percentage contribution of the capital resource in the MBMW sectors to total defense production requirements for capital stock. The _magnitude_ of these percentage estimates are influenced by the elimination of previous methodology errors, as reflected in the comparison of the original and modified estimates by Bill Lee and the CIA, respectively. The _trend_ with respect to the percentage estimates are influenced by the selection of estimating technique, as reflected in a comparison of the modified Lee and Stanley Cohn estimates (i.e., Columns 5 and 6 of Table 3.13b, which do not include military RDT&E, have trends in _opposite_ directions).[239] Consequently, in order to provide an ex post resource allocation analysis of the estimated composition of Soviet NSE that will be relatively _insensitive_ to the selection of estimating technique, a more general evaluation of the sectoral disaggregation of estimated Soviet defense expenditures must be performed. This more general methodology is based upon the concept of the _incidence pattern_ of sectoral burden ratios among qualitative resource categories (i.e., _skills_ for the labor resource and _durability_ for the capital resource) and is developed in detail in Appendix B. The essence of this concept is that an increasing _trend_ in the estimated sectoral economic burden ratios over time implies a transfer of resources from civilian to defense usage. Therefore, in the case of an increase in the estimated Soviet NSE for each sector over time, an increasing proportion of the labor and capital resources are generally required in most of the economic sectors in order to sustain this defense build-up. The sectoral growth rates for Soviet defense spending originally defined in Equation (73) are estimated in Table 3.14. However, it is possible for resource productivity and resource supply to increase so rapidly in certain economic sectors that the _estimated_ Soviet economic burden ratios for those sectors would _not_ increase over time. These conditions with respect to resource productivity and resource supply for each sector and each qualitative category (i.e., labor skills and capital durability) are _independently_ estimated in Appendix B of this report. Consequently, it is possible for the alternative baseline techniques used to estimate the sectoral composition of Soviet NSE to yield a _declining_ economic burden ratio for a particular category of labor skill or capital durability within a given sector. Although the _magnitude_ of these burden ratios will be

[239] Columns 10 and 11 of Table 3.13b, which include military RDT&E, also have trends in _opposite_ directions, but the rates of change per annum are substantially different than the entries _without_ military RDT&E.

Table 3.14

Sectoral Growth Rates for Alternative Estimates of Soviet NSE (1966-1971) [240]

1	2	3	4	5	6	7	8
Row	Sector	Growth Rate in the Estimated Soviet NSE, Excluding Military RDT&E Expenditures			Growth Rate in the Estimated Soviet NSE, Including Military RDT&E Expenditures		
		Original Lee	Modified Lee	Stanley Cohn	Original Lee	Modified Lee	Stanley Cohn
1	Agriculture	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2	Fuels	5.5%	5.5%	5.4%	5.2%	5.1%	6.0%
3	Metals	0.0%	0.0%	0.0%	0.0%	0.0%	10.2%
4	Machine-Building	22.2%	25.7%	11.9%	16.7%	17.0%	11.2%
5	Metalworking	18.0%	16.2%	5.1%	18.0%	16.2%	5.1%
6	Construction Materials	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	Chemicals	12.1%	12.1%	0.0%	12.5%	12.5%	0.0%
8	Food	5.6%	6.1% (6.1%)	5.4% (5.6%)	5.6%	5.9% (5.9%)	9.9% (7.5%)
9	Light Industry	3.7%	4.7% (4.8%)	6.8% (6.4%)	3.7%	4.7% (4.8%)	4.7% (8.3%)
10	Construction	5.9%	5.9%	5.6%	9.6%	9.6%	5.6%
11	Transportation and Communication	0.0%	0.0%	5.4%	0.0%	0.0%	5.4%
12	Trade and Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

[240] Sources of the data presented in Table 3.14 are as follows:

- Column 3 is based upon Table B-7a;
- Column 4 is based upon Table 3.7;
- Column 5 is based upon Table B-8a;
- Column 6 is based upon Table B-7b;
- Column 7 is based upon Table 3.8;
- Column 8 is based upon Table B-8b; and
- The sectoral growth rates "r_{ij}" for j = 1,..., 12 sectors and the ith estimating technique are estimated by means of the formula for "r_k" in Table B-33 of Appendix B.

influenced by the selection of the estimating technique, the trend in these economic burden ratios may be insensitive to the particular estimating technique that is selected. As a result, the possible existence of a burden incidence pattern "common" to all of the baseline estimating techniques will permit the formulation of some preliminary resource allocation conclusions concerning Soviet resource productivity and resource supply changes over time for those economic sectors and qualitative resource categories which are affected.[241] Those qualitative resource categories with constant or decreasing sectoral burden ratios, despite an increase in the overall sectoral economic burden ratio, would indicate that these qualitative resource categories have been more available for the support of civilian production than for defense production. By contrast, those qualitative resource categories upon which the incidence of defense burden increases over time reflect a transfer of resources from civilian to defense production.

3.6.5 Economic Burden Ratios

The concept of the direct and indirect economic burden of the estimated Soviet defense spending developed in Appendix B is represented by the percentage of a given resource utilized in a given economic sector for a given time period that is required to support the level and composition of Soviet NSE. This percentage is the Soviet economic burden ratio for the labor resource in Equation (B-17) and for the capital resource in Equation (B-18) of Appendix B. Although the level and sectoral composition of the estimated Soviet NSE may be increasing over time, it is possible that certain sectors will have non-increasing economic burden ratios over time. Also, even if the overall economic burden ratio of a sector is increasing over time, it is possible that the impact upon a particular category of labor skill or capital durability will reflect a non-increasing economic burden ratio for that particular qualitative resource category. This suggests that the "burden incidence pattern" will have an impact on those sectors or upon those qualitative resource categories with increasing sectoral

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[241] Although time series estimates for the sectoral composition of Soviet NSE are only available at the present time for two of the eight baseline methodologies (i.e., Bill Lee's and Stanley Cohn's), they do represent the two alternative "characterizations" that are usually associated with a given baseline estimating methodology. Bill Lee's estimates of the level of Soviet NSE over time yields an increasing share of Soviet NMP or GNP, whereas, Stanley Cohn's estimates yield a constant share.

burden ratios.[242] All of the sectoral burden ratios for categories of Soviet labor skills are estimated by means of Equation (B-19) and for categories of capital durability by means of Equation (B-21) in Appendix B. The "fundamental" burden incidence pattern for the labor and capital resources that is not sensitive to the selection of baseline estimating technique is derived from Tables 3.15, 3.16, 3.17, 3.18, and 3.19 which follow.

As may be observed in Table 3.15, the economic burden ratios for the Soviet labor resource are presented for each of the twelve economic sectors and three estimation techniques for the period 1966-1971. Generally speaking, the magnitude of the estimated economic burden ratio within each economic sector is greatly influenced by the choice of estimation technique. For example, in the Agricultural sector, Bill Lee's original estimation technique in Row 1a indicates that the labor burden ratio has increased from .1237 (i.e., 12.37 percent) to .1511 (i.e., 15.11 percent), which reflects the relative increase in the percentage of the Soviet agricultural labor force that was employed directly or indirectly in Soviet defense production during the period 1966-1971. However, the modified Lee estimation technique in Row 1b indicates that the labor burden ratio has increased from .2166 (i.e., 21.66 percent) in 1966 to .2589 (i.e., 25.89 percent) in 1971 utilizing the 64% & 36% hypothesis with regard to the consumption pattern for military pay in the Food and Light Industry sectors, respectively (i.e., the entries in Table 3.15 without parentheses).[243] Although the magnitude of the estimated economic burden ratio has greatly increased, the trend is still increasing--which is indicated by a "+" entry in Column 9 of Rows 1a and 1b.

[242] The concept of a "burden incidence pattern" is based upon the incidence of budget expenditure concept used in public finance, but modified in Appendix B of this report to reflect qualitative categories of resources by sector instead of the distribution of household incomes by size for indicating the "pattern of change". This burden incidence pattern reflects the transfer of resources from civilian production requirements to various sectors and resource categories for the purpose of sustaining increased defense production. In this context, see R.A. Musgrave and P.B. Musgrave, Public Finance in Theory and Practice, McGraw-Hill, New York, 1973, pages 356-358.

[243] The entries with parentheses reflect the alternative 50% & 50% hypothesis with respect to expenditures in the Food and Light Industry sectors.

Table 3.15

Economic Burden Ratios for the Soviet Labor Resource by Economic Sector (1966-1971) [243]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Aggregate Sectoral Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.1237	.1284	.1334	.1480	.1423	.1511	+
1b	Agriculture/ Modified Lee	.2166 (.2039)	.2229 (.2092)	.2331 (.2200)	.2654 (.2489)	.2419 (.2283)	.2589 (.2442)	+ (+)
1c	Agriculture/ Stanley Cohn	.2406 (.2307)	.2594 (.2346)	.2693 (.2430)	.3148 (.2845)	.3097 (.2799)	.3229 (.2912)	+ (+)
2a	Fuels/ Original Lee	.2712	.2853	.3041	.3164	.3248	.3435	+
2b	Fuels/ Modified Lee	.2723 (.2727)	.2831 (.2835)	.3001 (.3006)	.3127 (.3132)	.3172 (.3177)	.3335 (.3340)	+ (+)
2c	Fuels/ Stanley Cohn	.4018 (.4021)	.4109 (.4117)	.4597 (.4606)	.4658 (.4667)	.4509 (.4518)	.4203 (.4213)	+ (+)
3a	Metals/ Original Lee	.2444	.2675	.3055	.3332	.3582	.3940	+
3b	Metals/ Modified Lee	.2294 (.2301)	.2466 (.2474)	.2803 (.2810)	.3089 (.3097)	.3256 (.3263)	.3556 (.3564)	+ (+)
3c	Metals/ Stanley Cohn	.1654 (.1660)	.1654 (.1668)	.1810 (.1825)	.1949 (.1965)	.2038 (.2054)	.1992 (.2009)	+ (+)
4&5 a	MBMW/ Original Lee	.2964	.3159	.3420	.3500	.3609	.3748	+
4&5 b	MBMW/ Modified Lee	.2659 (.2659)	.2797 (.2797)	.3019 (.3019)	.3112 (.3112)	.3174 (.3174)	.3271 (.3271)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.1761 (.1761)	.1723 (.1723)	.1803 (.1803)	.1804 (.1804)	.1805 (.1805)	.1644 (.1644)	* (*)

[243] Sources of the data presented in Table 3.15 are as follows:

- Bill Lee's original burden ratios use the data in Table B-7b, as well as Equation (B-17) in Appendix B.
- Bill Lee's modified burden ratios use the data in Table 3.8, as well as Equation (B-17) in Appendix B.
- Stanley Cohn's burden ratios use the data in Table B-8b, as well as Equation (B-17) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "+-" indicates a cyclical pattern, and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include the technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.15 (continued)

Economic Burden Ratios for the Soviet Labor Resource by Economic Sector (1966-1971) 243

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Aggregate Sectoral Lauor Burden Ratios						Summary of The Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.3471	.3500	.3964	.3919	.4102	.4110	+
6b	Construction Materials/ Modified Lee	.3560 (.3584)	.3551 (.3575)	.4004 (.4026)	.3965 (.3990)	.4103 (.4124)	.4091 (.4112)	+ (+)
6c	Construction Materials/ Stanley Conn	.1936 (.1956)	.1885 (.1928)	.2040 (.2084)	.2102 (.2148)	.2016 (.2062)	.1880 (.1925)	* (*)
7a	Chemicals/ Original Lee	.2289	.2305	.2369	.2410	.2396	.2440	+
7b	Chemicals/ Modified Lee	.2324 (.2347)	.2318 (.2340)	.2375 (.2395)	.2418 (.2439)	.2381 (.2398)	.2412 (.2430)	+ (+)
7c	Chemicals/ Stanley Conn	.0914 (.0932)	.0854 (.0893)	.0873 (.0912)	.0864 (.0903)	.0836 (.0875)	.0778 (.0815)	- (-)
8a	Food/ Original Lee	.0563	.0553	.0567	.0574	.0564	.0592	+
8b	Food/ Modified Lee	.1060 (.0959)	.1035 (.0930)	.1071 (.0972)	.1120 (.1005)	.1041 (.0943)	.1097 (.0994)	+ (+)
8c	Food/ Stanley Conn	.1221 (.1142)	.1274 (.1086)	.1323 (.1123)	.1418 (.1208)	.1438 (.1224)	.1469 (.1247)	+ (+)
9a	Light Industry/ Original Lee	.1172	.1103	.1152	.1155	.1147	.1131	-
9b	Light Industry/ Modified Lee	.1606 (.1777)	.1489 (.1660)	.1567 (.1724)	.1579 (.1756)	.1516 (.1666)	.1513 (.1666)	- (-)
9c	Light Industry/ Stanley Cohn	.1543 (.1676)	.1324 (.1631)	.1332 (.1645)	.1376 (.1702)	.1369 (.1696)	.1357 (.1690)	- (+)
10a	Construction/ Original Lee	.1771	.1723	.2028	.1934	.2051	.1930	+
10b	Construction/ Modified Lee	.1771 (.1771)	.1723 (.1723)	.2028 (.2028)	.1934 (.1934)	.2051 (.2051)	.1930 (.1930)	+ (+)
10c	Construction/ Stanley Cohn	.0567 (.0567)	.0553 (.0553)	.0635 (.0635)	.0655 (.0655)	.0586 (.0586)	.0513 (.0513)	* (*)
11a	Transportation and Communication/ Original Lee	.0667	.0691	.0771	.0802	.0842	.0883	+
11b	Transportation and Communication/ Modified Lee	.0679 (.0681)	.0692 (.0694)	.0768 (.0769)	.0800 (.0802)	.0827 (.0828)	.0860 (.0862)	+ (+)
11c	Transportation and Communication/ Stanley Cohn	.1094 (.1095)	.1091 (.1095)	.1192 (.1195)	.1237 (.1241)	.1164 (.1168)	.1076 (.1079)	* (*)
12a	Trade and Distribution/ Original Lee	.0364	.0376	.0408	.0415	.0427	.0452	+
12b	Trade and Distribution/ Modified Lee	.0419 (.0413)	.0423 (.0417)	.0453 (.0447)	.0463 (.0456)	.0463 (.0457)	.0485 (.0479)	+ (+)
12c	Trade and Distribution/ Stanley Cohn	.0385 (.0380)	.0383 (.0371)	.0401 (.0389)	.0410 (.0397)	.0407 (.0395)	.0394 (.0381)	+ (*)

The selection of Stanley Cohn's estimation technique also increases the magnitude of the labor burden ratio in the Agricultural sector--which may be observed in Row 1c of Table 3.15 wherein the estimated labor burden ratio has increased from .2406 (i.e., 24.06 percent) in 1966 to .3229 (i.e., 32.29 percent) in 1971, again using the 64% & 36% hypothesis with regard to expenditures in the Food and Light Industry sectors (i.e., the entries without parentheses). Clearly, the magnitudes of the estimated agricultural labor burden ratios in Row 1c are almost twice those in Row 1a, but the trend is still increasing, so a "+" appears in Column 9, Row 1c of Table 3.15.[254] Although the cardinal magnitudes of the Soviet agricultural labor burden ratios are very sensitive not only to the choice of estimation technique, but also to the imposition of the disaggregation rules presented in Table 3.5, the ordinal trend is still increasing for the estimation techniques which were employed. Consequently, the entries in Column 9 of Rows 1a, 1b, and 1c are all "+", which indicates that Soviet defense expenditures resulted in an increasing labor burden ratio for the Agricultural sector during the period 1966-1971 for all of the estimation techniques applied. The same type of analysis may be applied to each of the other sectors in Table 3.15--as the result of which, it may be observed that following sectors are characterized by a non-decreasing trend for all of the estimation techniques applied:

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[254] This substantial increase in the magnitude of the Soviet agricultural labor burden ratios between Bill Lee's original estimation technique and Stanley Cohn's estimation technique, as well as between Bill Lee's original and modified estimates, reflects a substantial difference in the estimated percentage share of total civilian manpower engaged in Soviet defense production in the Agricultural sector. In this context, Steven Rosefielde made the following observation when he used Bill Lee's original estimation technique: "For example, 13.1% of Soviet civilian manpower involved in defense production is to be found in agriculture, as compared with 2.2% in the case of the U.S. If the influence of Soviet labor-intensive agriculture were eliminated, then the comparative labor intensity of the Soviet/U.S. labor force engaged in producing defense goods might be reversed." (Op. Cit., GE-TEMPO draft report, GE 76 TMP-54B, page 18.) If Steven Rosefielde had used instead the modified Lee estimates, the percentage of Soviet civilian manpower involved in defense production in the Agricultural sector would have increased to 19.6%, and if the Stanley Cohn estimation technique were applied, the same percentage would be increased to 26.1%. In other words, Steven Rosefielde's caveat is supported by using alternative estimation techniques.

- Agriculture (sector 1),
- Fuels (sector 2),
- Metals (sector 3),
- MBMW (sectors 4 and 5),
- Construction Materials (sector 6),
- Food (sector 8),
- Construction (sector 10),
- Transportation and Communication (sector 11), and
- Trade and Distribution (sector 12).

Only sector 7 (Chemicals) and sector 9 (Light Industry) reflect a sensitivity of the direction of the trend to the choice of estimation technique applied and to the hypothesis with respect to the expenditure pattern for military pay in the Food and Light Industry sectors.

Bill Lee's original and modified estimates in Rows 7a and 7b of Column 9 of the same table reveal an increasing labor burden ratio trend for the Chemical sector. By contrast, Stanley Cohn's estimates in Row 7c of Column 9 reflect a decreasing labor burden ratio trend for the Chemical sector. Clearly, the direction of the labor burden ratio trend for the Chemical sector depends crucially upon the choice of estimation technique.[255] As may also be observed, Bill Lee's original and modified estimates in Rows 9a and 9b of Column 9 reveal a decreasing labor burden ratio trend for the Light Industry sector, while Stanley Cohn's estimates in Row 9c of Column 9 reflect a sensitivity to the hypothesis adopted with respect to expenditure pattern for military pay. When the 64% & 36% hypothesis is used (i.e., the entries without parentheses), a decreasing labor burden ratio trend is observed in Row 9c of Column 9. However, when the 50% & 50% hypothesis is used (i.e., the entries with parentheses), then an increasing labor burden ratio trend is observed in

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[255] Inasmuch as the disaggregation rules presented in Table 3.5 were not applied by Stanley Cohn for the Chemical and Petrochemical sector (i.e., y^1_{7t} and z^1_{7t} were not separately estimated), this "probably" explains the difference between Rows 7a and 7b of Column 9, on the one hand, and Row 7c of Column 9, on the other hand. However, it is possible that other aspects of Stanley Cohn's estimation technique may explain this observed difference in the trend of the estimated burden ratio when compared with the trend of the estimated burden ratio utilizing Bill Lee's estimation technique.

Row 9c of Column 9. At the aggregate level of the Soviet labor resource in Table 3.15, there are no sectoral burden ratios which exhibit a non-increasing trend characteristic of all of the estimation techniques considered.

Proceeding now to Tables 3.16a, 3.16b, and 3.16c, it may be observed that the economic burden ratios for the Soviet labor resource are partitioned according to three skill categories for the period 1966-1971. In Table 3.16a, the high-skill labor resource reveals a non-increasing trend in the sectoral burden ratios for the following sectors that is characteristic of all of the Soviet NSE estimation techniques considered:

- Construction Materials (sector 6) and
- Trade and Distribution (sector 12).

Apparently, these two sectors have not been impacted by the burden incidence of Soviet NSE on the high-skill labor resource insofar as the various estimation techniques considered are concerned. The Construction sector (i.e., 10), however, is sensitive to the choice of estimation techniques from the standpoint of determining the direction of the trend of the high-skill labor burden ratio. All of the remaining sectors reflect a non-increasing trend with respect to the high-skill labor burden ratio, so the burden incidence of Soviet NSE definitely falls upon them.

The middle-skill labor resource summarized in Table 3.16b displays an increasing trend in all of the sectoral burden ratios for the various estimation techniques considered. As a consequence, it is evident that the burden incidence of Soviet NSE pertaining to the middle-skill labor resource category falls upon all twelve of the economic sectors.

Finally, as may be observed in Table 3.16c, the low-skill labor resource category displays a decreasing trend in the sectoral burden ratios for the following economic sectors that is characteristic of all of the Soviet NSE estimation techniques considered:

- Fuels (sector 2),
- Chemicals (sector 7), and
- Light Industry (sector 9).

Table 3.16a

Economic Burden Ratios for the Soviet High-Skill Labor Resource by Economic Sector (1966-1971) [244]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral High-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0051	.0056	.0063	.0075	.0077	.0083	+
1b	Agriculture/ Modified Lee	.0089 (.0084)	.0098 (.0092)	.0110 (.0103)	.0135 (.0127)	.0131 (.0123)	.0142 (.0134)	+ (+)
1c	Agriculture/ Stanley Cohn	.0099 (.0095)	.0114 (.0103)	.0127 (.0114)	.0161 (.0145)	.0167 (.0151)	.0178 (.0160)	+ (+)
2a	Fuels/ Original Lee	.0556	.0616	.0703	.0797	.0900	.1013	+
2b	Fuels/ Modified Lee	.0558 (.0559)	.0611 (.0612)	.0693 (.0694)	.0788 (.0789)	.0879 (.0880)	.0984 (.0985)	+ (+)
2c	Fuels/ Stanley Cohn	.0824 (.0824)	.0887 (.0889)	.1062 (.1064)	.1174 (.1176)	.1249 (.1252)	.1240 (.1243)	+ (+)
3a	Metals/ Original Lee	.0174	.0198	.0220	.0258	.0287	.0335	+
3b	Metals/ Modified Lee	.0163 (.0163)	.0182 (.0183)	.0202 (.0202)	.0238 (.0238)	.0260 (.0261)	.0302 (.0303)	+ (+)
3c	Metals/ Stanley Cohn	.0117 (.0118)	.0122 (.0123)	.0130 (.0131)	.0150 (.0151)	.0163 (.0164)	.0169 (.0171)	+ (+)
4&5 a	MBMW/ Original Lee	.0590	.0644	.0722	.0774	.0845	.0896	+
4&5 b	MBMW/ Modified Lee	.0529 (.0529)	.0571 (.0571)	.0637 (.0637)	.0688 (.0688)	.0743 (.0743)	.0782 (.0782)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.0350 (.0350)	.0352 (.0352)	.0380 (.0380)	.0399 (.0399)	.0422 (.0422)	.0393 (.0393)	+ (+)

[244] Sources of the data presented in Table 3.16a are as follows:

- Bill Lee's original burden ratios use the data in Tables B-7b and B-16, as well as Equation (B-19) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.8 and B-16, as well as Equation (B-19) in Appendix B.
- Stanley Cohn's burden ratios use the data in Tables B-8b and B-16, as well as Equation (B-19) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an <u>increasing</u> trend, "-" indicates a <u>decreasing</u> trend, "o" indicates <u>no</u> perceptible trend, "±" indicates a <u>cyclical</u> pattern, and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (<u>including</u> military RDT&E) <u>expressed</u> in producer's prices. They also include the technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.16a (continued)

Economic Burden Ratios for the Soviet High-Skill Labor Resource by Economic Sector (1966-1971) [244]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral High-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.0056	.0060	.0059	.0059	.0053	.0053	o
6b	Construction Materials/ Modified Lee	.0057 (.0057)	.0060 (.0061)	.0060 (.0060)	.0059 (.0060)	.0053 (.0054)	.0053 (.0053)	- (-)
6c	Construction Materials/ Stanley Cohn	.0031 (.0031)	.0032 (.0033)	.0031 (.0031)	.0032 (.0032)	.0026 (.0027)	.0024 (.0025)	- (-)
7a	Chemicals/ Original Lee	.0499	.0507	.0557	.0593	.0635	.0669	+
7b	Chemicals/ Modified Lee	.0507 (.0512)	.0510 (.0515)	.0558 (.0563)	.0595 (.0600)	.0631 (.0636)	.0661 (.0666)	+ (+)
7c	Chemicals/ Stanley Conn	.0199 (.0203)	.0188 (.0197)	.0205 (.0214)	.0213 (.0222)	.0222 (.0232)	.0213 (.0223)	+ (+)
8a	Food/ Original Lee	.0030	.0030	.0033	.0036	.0039	.0043	+
8b	Food/ Modified Lee	.0056 (.0051)	.0056 (.0050)	.0062 (.0056)	.0069 (.0062)	.0072 (.0065)	.0080 (.0073)	+ (+)
8c	Food/ Stanley Conn	.0065 (.0061)	.0069 (.0059)	.0077 (.0065)	.0088 (.0075)	.0099 (.0084)	.0107 (.0091)	+ (+)
9a	Light Industry/ Original Lee	.0025	.0023	.0026	.0028	.0031	.0032	+
9b	Light Industry/ Modified Lee	.0034 (.0037)	.0031 (.0035)	.0036 (.0040)	.0038 (.0042)	.0041 (.0045)	.0042 (.0047)	+ (+)
9c	Light Industry/ Stanley Conn	.0032 (.0035)	.0028 (.0034)	.0031 (.0038)	.0033 (.0041)	.0037 (.0046)	.0038 (.0047)	+ (+)
10a	Construction/ Original Lee	.0147	.0146	.0170	.0168	.0174	.0164	+
10b	Construction/ Modified Lee	.0147 (.0147)	.0146 (.0146)	.0170 (.0170)	.0168 (.0168)	.0174 (.0174)	.0164 (.0164)	+ (+)
10c	Construction/ Stanley Conn	.0047 (.0047	.0047 (.0047)	.0053 (.0053)	.0057 (.0057)	.0050 (.0050)	.0044 (.0044)	o (o)
11a	Transportation and Communication/ Original Lee	.0055	.0059	.0067	.0074	.0081	.0087	+
11b	Transportation and Communication/ Modified Lee	.0056 (.0056)	.0069 (.0060)	.0067 (.0067)	.0074 (.0074)	.0079 (.0080)	.0084 (.0084)	+ (+)
11c	Transportation and Communication/ Stanley Conn	.0090 (.0090)	.0094 (.0094)	.0104 (.0104)	.0114 (.0114)	.0112 (.0112)	.0105 (.0106)	+ (+)
12a	Trade and Distribution/ Original Lee	.0001	.0002	.0002	.0002	.0001	.0001	o
12b	Trade and Distribution/ Modified Lee	.0002 (.0002)	.0002 (.0002)	.0002 (.0002)	.0002 (.0002)	.0001 (.0001)	.0001 (.0001)	o (o)
12c	Trade and Distribution/ Stanley Conn	.0002 (.0002)	.0002 (.0001)	.0002 (.0002)	.0002 (.0002)	.0001 (.0001)	.0001 (.0001)	o (o)

Table 3.16b

Economic Burden Ratios for the Soviet Middle-Skill Labor Resource by Economic Sector (1966-1971) 245

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Middle-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0438	.0490	.0498	.0580	.0556	.0594	+
1b	Agriculture/ Modified Lee	.0767 (.0722)	.0852 (.0799)	.0870 (.0821)	.1040 (.0976)	.0946 (.0893)	.1017 (.0960)	+ (+)
1c	Agriculture/ Stanley Conn	.0852 (.0817)	.0991 (.0896)	.1005 (.0907)	.1234 (.1115)	.1211 (.1094)	.1269 (.1144)	+ (+)
2a	Fuels/ Original Lee	.0298	.0331	.0414	.0465	.0542	.0601	+
2b	Fuels/ Modified Lee	.0299 (.0300)	.0328 (.0329)	.0408 (.0409)	.0460 (.0460)	.0530 (.0531)	.0584 (.0584)	+ (+)
2c	Fuels/ Stanley Conn	.0442 (.0442)	.0477 (.0478)	.0625 (.0626)	.0685 (.0686)	.0753 (.0755)	.0735 (.0737)	+ (+)
3a	Metals/ Original Lee	.0132	.0161	.0217	.0255	.0312	.0355	+
3b	Metals/ Modified Lee	.0124 (.0124)	.0148 (.0148)	.0199 (.0200)	.0235 (.0235)	.0283 (.0284)	.0320 (.0321)	+ (+)
3c	Metals/ Stanley Conn	.0089 (.0090)	.0099 (.0100)	.0129 (.0130)	.0148 (.0149)	.0177 (.0179)	.0179 (.0181)	+ (+)
4&5 a	MBMW/ Original Lee	.0258	.0281	.0356	.0378	.0440	.0461	+
4&5 b	MBMW/ Modified Lee	.0231 (.0231)	.0249 (.0249)	.0314 (.0314)	.0336 (.0336)	.0387 (.0387)	.0402 (.0402)	+ (+)
4&5 c	MBMW/ Modified Lee	.0153 (.0153)	.0153 (.0153)	.0187 (.0188)	.0195 (.0195)	.0220 (.0220)	.0202 (.0202)	+ (+)

245 Sources of the data presented in Table 3.16b are as follows:

- Bill Lee's original burden ratios use the data in Tables B-7b and B-17, as well as Equation (B-19) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.8 and B-17, as well as Equation (B-19) in Appendix B.
- Stanley Conn's burden ratios use the data in Tables B-8b and B-17, as well as Equation (B-19) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern, and a "non-increasing" trend is identified by either "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include the technological progress adjustment as defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.16b (continued)

Economic Burden Ratios for the Soviet Middle-Skill Labor Resource by Economic Sector (1966-1971) 245

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Middle-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.0042	.0046	.0067	.0071	.0098	.0099	+
6b	Construction Materials/ Modified Lee	.0043 (.0043)	.0046 (.0046)	.0068 (.0068)	.0071 (.0072)	.0098 (.0099)	.0098 (.0099)	+ (+)
6c	Construction Materials/ Stanley Conn	.0023 (.0023)	.0025 (.0025)	.0035 (.0035)	.0038 (.0039)	.0048 (.0049)	.0045 (.0046)	+ (+)
7a	Chemicals/ Original Lee	.0293	.0300	.0334	.0352	.0367	.0381	+
7b	Chemicals/ Modified Lee	.0298 (.0300)	.0301 (.0304)	.0335 (.0338)	.0353 (.0356)	.0364 (.0367)	.0376 (.0379)	+ (+)
7c	Chemicals/ Stanley Conn	.0117 (.0119)	.0111 (.0116)	.0123 (.0129)	.0126 (.0132)	.0128 (.0134)	.0121 (.0127)	+ (+)
8a	Food/ Original Lee	.0023	.0023	.0029	.0032	.0037	.0041	+
8b	Food/ Modified Lee	.0042 (.0038)	.0042 (.0038)	.0055 (.0050)	.0062 (.0055)	.0069 (.0062)	.0076 (.0069)	+ (+)
8c	Food/ Stanley Conn	.0049 (.0046)	.0052 (.0045)	.0067 (.0057)	.0078 (.0066)	.0095 (.0081)	.0101 (.0086)	+ (+)
9a	Light Industry Original Lee	.0068	.0065	.0090	.0095	.0111	.0114	+
9b	Light Industry Modified Lee	.0093 (.0103)	.0088 (.0098)	.0122 (.0134)	.0129 (.0144)	.0147 (.0162)	.0153 (.0168)	+ (+)
9c	Light Industry Stanley Conn	.0090 (.0097)	.0078 (.0096)	.0104 (.0128)	.0113 (.0140)	.0133 (.0164)	.0137 (.0171)	+ (+)
10a	Construction/ Original Lee	.0391	.0391	.0485	.0472	.0513	.0477	+
10b	Construction/ Modified Lee	.0391 (.0391)	.0391 (.0391)	.0485 (.0485)	.0472 (.0472)	.0513 (.0513)	.0477 (.0477)	+ (+)
10c	Construction/ Stanley Conn	.0125 (.0125)	.0125 (.0125)	.0152 (.0152)	.0160 (.0160)	.0146 (.0146)	.1027 (.0127)	+ (+)
11a	Transportation and Communication/ Original Lee	.0032	.0035	.0042	.0046	.0052	.0055	+
11b	Transportation and Communication/ Modified Lee	.0033 (.0033)	.0035 (.0035)	.0042 (.0042)	.0046 (.0046)	.0051 (.0051)	.0053 (.0053)	+ (+)
11c	Transportation and Communication/ Stanley Conn	.0052 (.0053)	.0055 (.0055)	.0066 (.0066)	.0071 (.0071)	.0072 (.0072)	.0067 (.0067)	+ (+)
12a	Trade and Distribution/ Original Lee	.0009	.0009	.0010	.0011	.0012	.0013	+
12b	Trade and Distribution/ Modified Lee	.0010 (.0010)	.0010 (.0010)	.0011 (.0011)	.0012 (.0012)	.0013 (.0013)	.0014 (.0013)	+ (+)
12c	Trade and Distribution/ Stanley Conn	.0009 (.0009)	.0009 (.0009)	.0010 (.0010)	.0011 (.0010)	.0011 (.0011)	.0011 (.0011)	+ (+)

Table 3.16c

Economic Burden Ratios for the Soviet Low-Skill Labor Resource by Economic Sector (1966-1971) [246]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Low-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0748	.0737	.0774	.0824	.0790	.0834	+
1b	Agriculture/ Modified Lee	.1310 (.1234)	.1280 (.1201)	.1352 (.1276)	.1478 (.1386)	.1343 (.1267)	.1429 (.1348)	+ (+)
1c	Agriculture/ Stanley Conn	.1455 (.1396)	.1489 (.1346)	.1562 (.1410)	.1754 (.1585)	.1719 (.1553)	.1783 (.1607)	+ (+)
2a	Fuels/ Original Lee	.1858	.1906	.1925	.1902	.1806	.1820	-
2b	Fuels/ Modified Lee	.1865 (.1868)	.1891 (.1894)	.1900 (.1903)	.1879 (.1882)	.1764 (.1766)	.1768 (.1770)	- (-)
2c	Fuels/ Stanely Conn	.2752 (.2755)	.2745 (.2750)	.2910 (.2916)	.2799 (.2805)	.2507 (.2512)	.2228 (.2233)	- (-)
3a	Metals/ Original Lee	.2138	.2317	.2618	.2839	.2984	.3251	+
3b	Metals/ Modified Lee	.2007 (.2013)	.2135 (.2142)	.2402 (.2408)	.2616 (.2623)	.2712 (.2718)	.2934 (.2940)	+ (+)
3c	Metals/ Stanley Conn	.1448 (.1453)	.1432 (.1444)	.1552 (.1564)	.1651 (.1664)	.1693 (.1711)	.1643 (.1657)	+ (+)
4&5 a	MBMW/ Original Lee	.2116	.2234	.2343	.2349	.2324	.2391	+
4&5 b	MBMW/ Modified Lee	.1899 (.1399)	.1977 (.1977)	.2068 (.2068)	.2088 (.2088)	.2044 (.2044)	.2087 (.2087)	+ (+)
4&5 c	MBMW/ Stanley Conn	.1257 (.1257)	.1218 (.1218)	.1235 (.1235)	.1210 (.1210)	.1162 (.1162)	.1049 (.1049)	- (-)

[246] Sources of the data presented in Table 3.16c are as follows:

- Bill Lee's original burden ratios use the data in Tables 3-7b and 8-18, as well as Equation (B-19) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.8 and B-18, as well as Equation (B-19) in Appendix B.
- Stanley Conn's burden ratios use the data in Tables B-8b and B-18, as well as Equation (B-19) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern, and a "non-increasing" trend is identified by either "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include the technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 34% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.16c (continued)

Economic Burden Ratios for the Soviet Low-Skill Labor Resource by Economic Sector (1966-1971) 246

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Low-Skill Labor Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.3374	.3395	.3837	.3789	.3950	.3958	+
6b	Construction Materials/ Modified Lee	.3461 (.3483)	.3445 (.3468)	.3876 (.3897)	.3834 (.3858)	.3951 (.3971)	.3940 (.3960)	+ (+)
6c	Construction Materials/ Stanley Cohn	.1883 (.1901)	.1828 (.1870)	.1975 (.2017)	.2033 (.2077)	.1942 (.1986)	.1810 (.1854)	+ (+)
7a	Chemicals/ Original Lee	.1497	.1498	.1478	.1465	.1394	.1391	-
7b	Chemicals/ Modified Lee	.1520 (.1535)	.1506 (.1521)	.1482 (.1494)	.1470 (.1483)	.1386 (.1396)	.1375 (.1385)	- (-)
7c	Chemicals/ Stanley Cohn	.0598 (.0609)	.0555 (.0581)	.0545 (.0569)	.0525 (.0549)	.0487 (.0509)	.0443 (.0464)	- (-)
8a	Food/ Original Lee	.0510	.0500	.0505	.0507	.0488	.0508	o
8b	Food/ Modified Lee	.0962 (.0869)	.0936 (.0842)	.0955 (.0866)	.0989 (.0888)	.0900 (.0816)	.0941 (.0853)	- (-)
8c	Food/ Stanley Cohn	.1107 (.1035)	.1153 (.0983)	.1179 (.1001)	.1252 (.1066)	.1243 (.1059)	.1261 (.1070)	+ (+)
9a	Light Industry/ Original Lee	.1080	.1015	.1036	.1032	.1005	.0985	-
9b	Light Industry/ Modified Lee	.1480 (.1636)	.1370 (.1527)	.1409 (.1550)	.1412 (.1570)	.1328 (.1459)	.1317 (.1451)	- (-)
9c	Light Industry/ Stanley Cohn	.1421 (.1543)	.1218 (.1501)	.1198 (.1479)	.1230 (.1521)	.1199 (.1486)	.1182 (.1472)	- (-)
10a	Construction/ Original Lee	.1233	.1185	.1373	.1294	.1364	.1289	+
10b	Construction/ Modified Lee	.1233 (.1233)	.1185 (.1185)	.1373 (.1373)	.1294 (.1294)	.1364 (.1364)	.1289 (.1289)	+ (+)
10c	Construction/ Stanley Cohn	.0394 (.0394)	.0380 (.0380)	.0430 (.0430)	.0438 (.0438)	.0390 (.0390)	.0343 (.0343)	- (-)
11a	Transportation and Communication Original Lee	.0581	.0597	.0662	.0682	.0709	.0742	+
11b	Transportation and Communication Modified Lee	.0591 (.0592)	.0598 (.0599)	.0659 (.0660)	.0681 (.0682)	.0696 (.0698)	.0723 (.0724)	+ (+)
11c	Transportation and Communication Stanley Cohn	.0952 (.0953)	.0943 (.0946)	.1023 (.1026)	.1053 (.1056)	.0980 (.0983)	.0904 (.0907)	o (o)
12a	Trade and Distribution/ Original Lee	.0354	.0365	.0396	.0402	.0414	.0438	+
12b	Trade and Distribution/ Modified Lee	.0408 (.0401)	.0411 (.0405)	.0440 (.0434)	.0449 (.0443)	.0448 (.0443)	.0470 (.0464)	+ (+)
12c	Trade and Distribution/ Stanley Cohn	.0374 (.0369)	.0372 (.0361)	.0390 (.0378)	.0398 (.0385)	.0395 (.0382)	.0381 (.0369)	+ (+)

In other words, these sectors have not been impacted by the burden incidence of Soviet NSE insofar as the aforementioned estimation techniques are concerned. However, the following economic sectors are sensitive to the choice of estimation technique from the standpoint of determining the direction of the trend of the low-skill labor burden ratio:

- MBMW (sectors 4 and 5),
- Food (sector 8),
- Construction (sector 10), and
- Transportation and Communication (sector 11).

All of the remaining sectors in Table 3.16c reflect a non-decreasing trend with respect to the low-skill labor burden ratio, so the burden incidence of Soviet NSE definitely falls upon them.

In Table 3.17, the economic burden ratios for the Soviet capital resource are presented for each of the twelve sectors and the three estimation techniques considered for the period 1966-1971. Generally speaking, the magnitude of the estimated economic burden ratio for each economic sector is greatly influenced by the choice of estimation technique. However, the trend of the estimated economic burden ratios for the Soviet capital resource is more robust, and the following sectors are characterized by a non-decreasing trend for the various estimation techniques considered:

- Agriculture (sector 1),
- Fuels (sector 2),
- Metals (sector 3),
- Construction Materials (sector 6),
- Food (sector 8),
- Construction (sector 10), and
- Transportation and Communication (sector 11).

As may be observed in Table 3.17, the following sectors reflect a sensitivity of the direction of the trend to the choice of estimation technique and to the hypothesis with respect to the expenditure pattern for military pay in the Food and Light Industry sectors:

Table 3.17

Economic Burden Ratios for the Soviet Capital Resource by Economic Sector (1966-1971) [247]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Aggregate Sectoral Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0220	.0228	.0237	.0263	.0252	.0268	+
1b	Agriculture/ Modified Lee	.0384 (.0362)	.0396 (.0371)	.0414 (.0390)	.0471 (.0442)	.0429 (.0405)	.0459 (.0433)	+ (+)
1c	Agriculture/ Stanley Cohn	.0427 (.0409)	.0460 (.0416)	.0478 (.0431)	.0559 (.0505)	.0550 (.0497)	.0573 (.0517)	+ (+)
2a	Fuels/ Original Lee	.2038	.2144	.2284	.2377	.2443	.2581	+
2b	Fuels/ Modified Lee	.2046 (.2049)	.2127 (.2131)	.2254 (.2258)	.2348 (.2352)	.2386 (.2389)	.2506 (.2510)	+ (+)
2c	Fuels/ Stanley Cohn	.3019 (.3022)	.3088 (.3094)	.3453 (.3460)	.3499 (.3506)	.3391 (.3398)	.3158 (.3166)	+ (+)
3a	Metals/ Original Lee	.2303	.2521	.2880	.3159	.3376	.3715	+
3b	Metals/ Modified Lee	.2162 (.2169)	.2324 (.2331)	.2643 (.2649)	.2911 (.2919)	.3068 (.3075)	.3353 (.3360)	+ (+)
3c	Metals/ Stanley Cohn	.1559 (.1565)	.1559 (.1572)	.1707 (.1721)	.1837 (.1852)	.1921 (.1936)	.1878 (.1894)	+ (+)
4&5 a	MBMW/ Original Lee	.2063	.2198	.2379	.2439	.2512	.2612	+
4&5 b	MBMW/ Modified Lee	.1857 (.1857)	.1950 (.1950)	.2104 (.2104)	.2173 (.2173)	.2211 (.2211)	.2283 (.2283)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.1201 (.1201)	.1175 (.1175)	.1229 (.1229)	.1229 (.1229)	.1228 (.1228)	.1117 (.1117)	- (-)

[247] Sources of the data presented in Table 3.17 are as follows:

- Bill Lee's original burden ratios use the data in Table B-7b, as well as Equation (B-18) in Appendix B.
- Bill Lee's modified burden ratios use the data in Table 3.8, as well as Equation (B-18) in Appendix B.
- Stanley Cohn's burden ratios use the data in Table B-8b, as well as Equation (B-18) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include a technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.17 (continued)

Economic Burden Ratios for the Soviet Capital Resource by Economic Sector (1966-1971) 247

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Aggregate Sectoral Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.1636	.1650	.1870	.1846	.1933	.1937	+
6b	Construction Materials/ Modified Lee	.1678 (.1689)	.1674 (.1686)	.1889 (.1899)	.1868 (.1880)	.1934 (.1944)	.1928 (.1938)	+ (+)
6c	Construction Materials/ Stanley Cohn	.0913 (.0922)	.0889 (.0909)	.0962 (.0983)	.0990 (.1012)	.0950 (.0972)	.0886 (.0908)	+ (+)
7a	Chemicals/ Original Lee	.1567	.1577	.1620	.1650	.1640	.1670	+
7b	Chemicals/ Modified Lee	.1591 (.1606)	.1586 (.1601)	.1624 (.1638)	.1655 (.1670)	.1630 (.1642)	.1651 (.1663)	+ (+)
7c	Chemicals/ Stanley Cohn	.0626 (.0638)	.0584 (.0611)	.0597 (.0624)	.0592 (.0613)	.0573 (.0599)	.0532 (.0558)	- (-)
8a	Food/ Original Lee	.0284	.0279	.0286	.0289	.0284	.0298	+
8b	Food/ Modified Lee	.0534 (.0483)	.0522 (.0469)	.0540 (.0490)	.5064 (.0507)	.0525 (.0476)	.0553 (.0501)	+ (+)
8c	Food/ Stanley Lee	.0615 (.0575)	.0642 (.0548)	.0667 (.0566)	.0715 (.0609)	.0725 (.0617)	.0740 (.0628)	+ (+)
9a	Light Industry/ Original Lee	.1132	.1066	.1113	.1116	.1109	.1093	-
9b	Light Industry/ Modified Lee	.1552 (.1716)	.1439 (.1604)	.1514 (.1665)	.1525 (.1697)	.1466 (.1610)	.1461 (.1609)	- (-)
9c	Light Industry/ Stanley Cohn	.1491 (.1619)	.1280 (.1576)	.1287 (.1589)	.1330 (.1644)	.1323 (.1639)	.1311 (.1632)	- (+)
10a	Construction/ Original Lee	.0731	.0711	.0837	.0798	.0846	.0796	+
10b	Construction/ Modified Lee	.0731 (.0731)	.0711 (.0711)	.0837 (.0837)	.0798 (.0798)	.0846 (.0846)	.0796 (.0796)	+ (+)
10c	Construction/ Stanley Cohn	.0234 (.0234)	.0228 (.0228)	.0262 (.0262)	.0270 (.0270)	.0242 (.0242)	.0212 (.0212)	+ (+)
11a	Transportation and Communication/ Original Lee	.0118	.0122	.0136	.0141	.0148	.0156	+
11b	Transportation and Communication/ Modified Lee	.0120 (.0120)	.0122 (.0122)	.0135 (.0135)	.0141 (.0141)	.01[illegible] (.01[illegible]6)	.0152 (.0152)	+ (+)
11c	Transportation and Communication/ Stanley Cohn	.0193 (.0193)	.0192 (.0193)	.0210 (.0211)	.0218 (.0219)	.0205 (.0206)	.0190 (.0190)	+ (+)
12a	Trade and Distribution/ Original Lee	.0081	.0084	.0091	.0092	.0095	.0101	+
12b	Trade and Distribution/ Modified Lee	.0093 (.0092)	.0094 (.0093)	.0101 (.0099)	.0103 (.0102)	.0103 (.0102)	.0108 (.0107)	+ (+)
12c	Trade and Distribution/ Stanley Cohn	.0086 (.0084)	.0085 (.0083)	.0089 (.0087)	.0091 (.0088)	.0091 (.0088)	.0088 (.0085)	o (o)

- MBMW (sectors 4 and 5),
- Chemicals (sector 7),
- Light Industry (sector 9), and
- Trade and Distribution (sector 12).

The type of analysis applied to the labor resource in Table 3.15 may also be applied to the capital resource in Table 3.17. It may also be observed that the MBMW composite sector and the Trade and Distribution sector for the capital resource reveal a sensitivity to the choice of estimation technique with respect to the direction of the burden ratio trend that did not exist for the labor resource. However, at the aggregate level of the Soviet capital resource in Table 3.17, there are no sectoral burden ratios which exhibit non-increasing trends that are characteristic of all of Soviet NSE estimation techniques considered. As was the case with the labor resource, it will be necessary to partition the capital resource into various qualitative categories in order to obtain certain sectoral burden ratios which will exhibit non-increasing trends that are characteristic of the Soviet NSE estimation techniques considered.

Turning now to Tables 3.18a, 3.18b, and 3.18c, it may be observed that the economic burden ratios for the Soviet capital resource are partitioned according to the three durability categories for the period 1966-1971. In Table 3.18a, the high-durability capital resource reflects a sensitivity to the choice of estimation technique in the determination of the direction of the trend of the high-durability capital burden ratio in the following sectors:

- MBMW (sectors 4 and 5),
- Chemicals (sector 7),
- Light Industry (sector 9),
- Construction (sector 10), and
- Transportation and Communication (sector 11).

Of particular interest is the Light Industry sector wherein a comparison of the entries in Rows 9a and 9b of Column 9 in Table 3.18c reveal a sensitivity to the general disaggregation rules presented in Table 3.5. In addition, the entries in Row 9c and Column 9 of the same table display a sensitivity to the hypothesis with respect to the expenditure pattern for military pay in the Food and Light Industry sectors. All of the remaining sectors enhibit a non-decreasing trend

Table 3.18a

Economic Burden Ratios for the Soviet High-Durability Capital Resource by Economic Sector (1966-1971) [248]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral High-Durability Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0077	.0080	.0082	.0091	.0085	.0090	+
1b	Agriculture/ Modified Lee	.0136 (.0128)	.0140 (.0131)	.0144 (.0136)	.0163 (.0153)	.0144 (.0136)	.0153 (.0145)	+ (+)
1c	Agriculture/ Stanley Cohn	.0151 (.0145)	.0162 (.0147)	.0166 (.0150)	.0194 (.0175)	.0185 (.0167)	.0191 (.0173)	+ (+)
2a	Fuels/ Original Lee	.1368	.1422	.1521	.1550	.1630	.1680	+
2b	Fuels/ Modified Lee	.1373 (.1375)	.1410 (.1413)	.1501 (.1504)	.1531 (.1534)	.1592 (.1594)	.1632 (.1634)	+ (+)
2c	Fuels/ Stanley Cohn	.2026 (.2028)	.2047 (.2052)	.2300 (.2304)	.2281 (.2286)	.2262 (.2267)	.2056 (.2061)	* (*)
3a	Metals/ Original Lee	.1036	.1114	.1273	.1390	.1499	.1650	+
3b	Metals/ Modified Lee	.0973 (.0976)	.1027 (.1030)	.1168 (.1171)	.1281 (.1284)	.1362 (.1365)	.1489 (.1492)	+ (+)
3c	Metals/ Stanley Cohn	.0702 (.0704)	.0689 (.0695)	.0754 (.0760)	.0808 (.0815)	.0853 (.0860)	.0834 (.0841)	+ (+)
4&5 a	MBMW/ Original Lee	.0842	.0881	.0952	.1003	.1052	.1110	+
4&5 b	MBMW/ Modified Lee	.0758 (.0758)	.0782 (.0782)	.0842 (.0842)	.0893 (.0893)	.0926 (.0926)	.0970 (.0970)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.0490 (.0490)	.0471 (.0471)	.0492 (.0492)	.0505 (.0505)	.0515 (.0515)	.0475 (.0475)	o (o)

[248] Sources of the data presented in Table 3.18a are as follows:

- Bill Lee's original burden ratios use the data in Tables B-7b and B-30, as well as Equation (B-21) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.3 and B-30, as well as Equation (B-21) in Appendix B.
- Stanley Cohn's burden ratios use the data in Tables B-8b and B-30, as well as Equation (B-21) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include a technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.18a (continued)

Economic Burden Ratios for the Soviet High-Durability Capital Resource by Economic Sector (1966-1971) 248

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral High-Durability Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.0892	.0885	.1000	.1016	.1083	.1104	+
6b	Construction Materials/ Modified Lee	.0915 (.0921)	.0897 (.0903)	.1011 (.1016)	.1027 (.1034)	.1083 (.1088)	.1099 (.1105)	+ (+)
6c	Construction Materials/ Stanley Conn	.0498 (.0502)	.0476 (.0487)	.0515 (.0526)	.0545 (.0557)	.0532 (.0544)	.0505 (.0517)	+ (+)
7a	Chemicals/ Original Lee	.0749	.0749	.0771	.0795	.0802	.0822	+
7b	Chemicals/ Modified Lee	.0760 (.0768)	.0753 (.0760)	.0773 (.0780)	.0798 (.0805)	.0797 (.0803)	.0812 (.0818)	+ (+)
7c	Chemicals/ Stanley Conn	.0299 (.0305)	.0277 (.0290)	.0284 (.0297)	.0285 (.0298)	.0280 (.0293)	.0262 (.0274)	- (-)
8a	Food/ Original Lee	.0092	.0090	.0093	.0100	.0098	.0106	+
8b	Food/ Modified Lee	.0173 (.0156)	.0168 (.0151)	.0177 (.0160)	.0194 (.0174)	.0182 (.0165)	.0197 (.0178)	+ (+)
8c	Food/ Stanley Conn	.0199 (.0186)	.0207 (.0176)	.0218 (.0185)	.0246 (.0209)	.0251 (.0214)	.0264 (.0224)	+ (+)
9a	Light Industry/ Original Lee	.0256	.0243	.0260	.0262	.0259	.0258	+
9b	Light Industry/ Modified Lee	.0351 (.0388)	.0328 (.0366)	.0354 (.0390)	.0358 (.0399)	.0343 (.0377)	.0345 (.0380)	- (-)
9c	Light Industry/ Stanley Conn	.0337 (.0366)	.0292 (.0359)	.0301 (.0372)	.0312 (.0386)	.0310 (.0384)	.0309 (.0385)	- (+)
10a	Construction/ Original Lee	.0161	.0155	.0177	.0173	.0184	.0169	+
10b	Construction/ Modified Lee	.0161 (.0161)	.0155 (.0155)	.0177 (.0177)	.0173 (.0173)	.0184 (.0184)	.0169 (.0169)	+ (+)
10c	Construction/ Stanley Conn	.0052 (.0052)	.0050 (.0050)	.0056 (.0056)	.0059 (.0059)	.0053 (.0053)	.0045 (.0045)	o (o)
11a	Transportation and Communication/ Original Lee	.0075	.0078	.0087	.0090	.0095	.0099	+
11b	Transportation and Communication/ Modified Lee	.0077 (.0077)	.0078 (.0078)	.0086 (.0087)	.0090 (.0090)	.0093 (.0093)	.0097 (.0097)	+ (+)
11c	Transportation and Communication/ Stanley Conn	.0123 (.0123)	.0123 (.0123)	.0134 (.0135)	.0139 (.0139)	.0131 (.0131)	.0121 (.0121)	o (o)
12a	Trade and Distribution/ Original Lee	.0019	.0020	.0023	.0022	.0023	.0024	+
12b	Trade and Distribution/ Modified Lee	.0022 (.0022)	.0022 (.0022)	.0026 (.0026)	.0025 (.0024)	.0024 (.0024)	.0025 (.0025)	+ (+)
12c	Trade and Distribution/ Stanley Conn	.0020 (.0020)	.0020 (.0020)	.0023 (.0022)	.0022 (.0021)	.0021 (.0021)	.0021 (.0020)	- (+)

Table 3.18b

Economic Burden Ratios for the Soviet Middle-Durability Capital Resource by Economic Sector (1966-1971) [249]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Middle-Durability Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0089	.0092	.0095	.0105	.0097	.0103	+
1b	Agriculture/ Modified Lee	.0156 (.0147)	.0161 (.0151)	.0166 (.0157)	.0188 (.0176)	.0166 (.0156)	.0176 (.0166)	+ (+)
1c	Agriculture/ Stanley Cohn	.0173 (.0166)	.0187 (.0169)	.0192 (.0173)	.0223 (.0201)	.0212 (.0192)	.0220 (.0198)	+ (+)
2a	Fuels/ Original Lee	.0599	.0622	.0665	.0680	.0711	.0733	+
2b	Fuels/ Modified Lee	.0602 (.0603)	.0617 (.0618)	.0656 (.0657)	.0672 (.0673)	.0694 (.0695)	.0712 (.0713)	+ (+)
2c	Fuels/ Stanley Cohn	.0888 (.0888)	.0895 (.0897)	.1005 (.1007)	.1001 (.1003)	.0987 (.0989)	.0897 (.0899)	+ (+)
3a	Metals/ Original Lee	.0852	.0913	.1048	.1141	.1232	.1349	+
3b	Metals/ Modified Lee	.0800 (.0802)	.0841 (.0844)	.0962 (.0964)	.1051 (.1054)	.1120 (.1123)	.1217 (.1220)	+ (+)
3c	Metals/ Stanley Cohn	.0577 (.0579)	.0564 (.0569)	.0621 (.0626)	.0663 (.0668)	.0701 (.0707)	.0682 (.0687)	+ (+)
4&5 a	MBMW/ Original Lee	.0534	.0560	.0607	.0637	.0668	.0703	+
4&5 b	MBMW/ Modified Lee	.0481 (.0481)	.0497 (.0497)	.0537 (.0537)	.0567 (.0567)	.0588 (.0588)	.0614 (.0614)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.0311 (.0311)	.0300 (.0300)	.0313 (.0313)	.0321 (.0321)	.0327 (.0327)	.0301 (.0301)	* (*)

[249] Sources of the data presented in Table 3.18b are as follows:

- Bill Lee's original burden ratios use the data in Tables B-7b and B-31, as well as Equation (B-21) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.8 and B-31, as well as Equation (B-21) in Appendix B.
- Stanley Cohn's burden ratios use the data in Tables B-8b and B-31, as well as Equation (B-21) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern, and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- *These sectoral aggregate* labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include a technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.18b (continued)

Economic Burden Ratios for the Soviet Middle-Durability Capital Resource by Economic Sector (1966-1971)

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Middle-Durability Capital Burden Ratios:						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.0535	.0536	.0600	.0611	.0653	.0668	+
6b	Construction Materials/ Modified Lee	.0549 (.0552)	.0544 (.0548)	.0606 (.0610)	.0618 (.0622)	.0654 (.0657)	.0665 (.0669)	+ (+)
6c	Construction Materials/ Stanley Conn	.0299 (.0301)	.0289 (.0295)	.0309 (.0316)	.0328 (.0335)	.0321 (.0329)	.0306 (.0313)	+ (+)
7a	Chemicals/ Original Lee	.0539	.0539	.0556	.0576	.0581	.0591	+
7b	Chemicals/ Modified Lee	.0547 (.0553)	.0542 (.0548)	.0557 (.0562)	.0578 (.0583)	.0577 (.0581)	.0585 (.0589)	+ (+)
7c	Chemicals/ Stanley Conn	.0215 (.0219)	.0200 (.0209)	.0205 (.0214)	.0206 (.0216)	.0203 (.0212)	.0188 (.0197)	- (-)
8a	Food/ Original Lee	.0087	.0086	.0088	.0095	.0094	.0101	+
8b	Food/ Modified Lee	.0165 (.0149)	.0160 (.0144)	.0167 (.0151)	.0185 (.0166)	.0173 (.0156)	.0187 (.0169)	+ (+)
8c	Food/ Stanley Conn	.0189 (.0177)	.0197 (.0168)	.0206 (.0175)	.0234 (.0200)	.0238 (.0203)	.0250 (.0212)	+ (+)
9a	Light Industry/ Original Lee	.0265	.0253	.0269	.0271	.0267	.0270	+
9b	Light Industry/ Modified Lee	.0363 (.0402)	.0341 (.0380)	.0366 (.0403)	.0371 (.0412)	.0353 (.0388)	.0361 (.0398)	- (-)
9c	Light Industry/ Stanley Conn	.0349 (.0379)	.0303 (.0374)	.0312 (.0385)	.0323 (.0400)	.0319 (.0395)	.0324 (.0403)	- (+)
10a	Construction/ Original Lee	.0345	.0330	.0378	.0370	.0394	.0360	+
10b	Construction/ Modified Lee	.0345 (.0345)	.0330 (.0330)	.0378 (.0378)	.0370 (.0370)	.0394 (.0394)	.0360 (.0360)	+ (+)
10c	Construction/ Stanley Conn	.0110 (.0110)	.0106 (.0106)	.0119 (.0119)	.0125 (.0125)	.0113 (.0113)	.0096 (.0096)	+ (+)
11a	Transportation and Communication/ Original Lee	.0041	.0042	.0047	.0049	.0051	.0054	+
11b	Transportation and Communication/ Original Lee	.0042 (.0042)	.0042 (.0042)	.0047 (.0047)	.0049 (.0049)	.0050 (.0051)	.0052 (.0053)	+ (+)
11c	Transportation and Communication/ Stanley Conn	.0067 (.0067)	.0067 (.0067)	.0073 (.0073)	.0075 (.0076)	.0071 (.0071)	.0066 (.0066)	+ (+)
12a	Trade and Distribution/ Original Lee	.0007	.0007	.0008	.0008	.0008	.0008	+
12b	Trade and Distribution/ Modified Lee	.0008 (.0007)	.0008 (.0008)	.0009 (.0009)	.0009 (.0008)	.0008 (.0008)	.0009 (.0009)	+ (+)
12c	Trade and Distribution/ Stanley Conn	.0007 (.0007)	.0007 (.0007)	.0008 (.0008)	.0008 (.0007)	.0007 (.0007)	.0007 (.0007)	o (o)

Table 3.18c

Economic Burden Ratios for the Soviet Low-Durability Capital Resource by Economic Sector (1966-1971) [250]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Low-Durability Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
1a	Agriculture/ Original Lee	.0053	.0055	.0059	.0067	.0070	.0076	+
1b	Agriculture/ Modified Lee	.0093 (.0087)	.0095 (.0089)	.0104 (.0098)	.0120 (.0112)	.0119 (.0113)	.0130 (.0122)	+ (+)
1c	Agriculture/ Stanley Cohn	.0103 (.0099)	.0111 (.0100)	.0120 (.0108)	.0142 (.0128)	.0153 (.0138)	.0162 (.0146)	+ (+)
2a	Fuels/ Original Lee	.0071	.0101	.0098	.0147	.0103	.0168	+
2b	Fuels/ Modified Lee	.0072 (.0072)	.0100 (.0100)	.0097 (.0097)	.0146 (.0146)	.0100 (.0100)	.0163 (.0163)	+ (+)
2c	Fuels/ Stanley Cohn	.0106 (.0106)	.0145 (.0145)	.0148 (.0149)	.0217 (.0217)	.0142 (.0143)	.0205 (.0206)	+ (+)
3a	Metals/ Original Lee	.0415	.0494	.0559	.0629	.0645	.0717	+
3b	Metals/ Modified Lee	.0389 (.0390)	.0455 (.0457)	.0513 (.0514)	.0579 (.0581)	.0586 (.0587)	.0647 (.0648)	+ (+)
3c	Metals/ Stanley Cohn	.0281 (.0282)	.0305 (.0308)	.0331 (.0334)	.0366 (.0368)	.0367 (.0370)	.0362 (.0365)	+ (+)
4&5 a	MBMW/ Original Lee	.0687	.0756	.0821	.0800	.0791	.0799	+
4&5 b	MBMW/ Modified Lee	.0618 (.0618)	.0671 (.0671)	.0726 (.0726)	.0713 (.0713)	.0696 (.0696)	.0699 (.0699)	+ (+)
4&5 c	MBMW/ Stanley Cohn	.0400 (.0400)	.0404 (.0404)	.0424 (.0424)	.0403 (.0403)	.0387 (.0387)	.0342 (.0342)	- (-)

[250] Sources of the data presented in Table 3.18c are as follows:

- Bill Lee's original burden ratios use the data in Tables B-7b and B-32, as well as Equation (B-21) in Appendix B.
- Bill Lee's modified burden ratios use the data in Tables 3.3 and B-32, as well as Equation (B-21) in Appendix B.
- Stanley Cohn's burden ratios use the data in Tables B-8b and B-32, as well as Equation (B-21) in Appendix B.
- Column 9 provides a summary of the burden ratio trends where "+" indicates an increasing trend, "-" indicates a decreasing trend, "o" indicates no perceptible trend, "*" indicates a cyclical pattern, and a "non-increasing" trend is identified by either a "-" or a "o" symbol.
- These sectoral aggregate labor burden ratios are based upon estimates of Soviet NSE (including military RDT&E) expressed in producer's prices. They also include a technological progress adjustment defined in Appendix B.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.18c (continued)

Economic Burden Ratios for the Soviet Low-Durability Capital Resource by Economic Sector (1966-1971)[250]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Sectoral Low-Durability Capital Burden Ratios						Summary of the Burden Ratio Trend
		1966	1967	1968	1969	1970	1971	
6a	Construction Materials/ Original Lee	.0209	.0229	.0269	.0220	.0197	.0165	-
6b	Construction Materials/ Modified Lee	.0215 (.0216)	.0233 (.0234)	.0272 (.0273)	.0222 (.0224)	.0197 (.0198)	.0164 (.0165)	- (-)
6c	Construction Materials/ Stanley Cohn	.0117 (.0118)	.0124 (.0126)	.0139 (.0142)	.0118 (.0120)	.0097 (.0099)	.0075 (.0077)	- (-)
7a	Chemicals/ Original Lee	.0279	.0289	.0293	.0279	.0258	.0257	-
7b	Chemicals/ Modified Lee	.0283 (.0286)	.0290 (.0293)	.0294 (.0296)	.0280 (.0282)	.0256 (.0258)	.0254 (.0256)	- (-)
7c	Chemicals/ Stanley Cohn	.0111 (.0114)	.0107 (.0112)	.0108 (.0113)	.0100 (.0104)	.0090 (.0094)	.0082 (.0086)	- (-)
8a	Food/ Original Lee	.0105	.0103	.0104	.0095	.0092	.0091	-
8b	Food/ Modified Lee	.0197 (.0178)	.0194 (.0174)	.0197 (.0178)	.0185 (.0166)	.0171 (.0155)	.0169 (.0153)	- (-)
8c	Food/ Stanley Cohn	.0227 (.0212)	.0238 (.0203)	.0243 (.0206)	.0234 (.0200)	.0236 (.0201)	.0227 (.0192)	+ (-)
9a	Light Industry/ Original Lee	.0611	.0570	.0583	.0582	.0582	.0565	-
9b	Light Industry/ Modified Lee	.0838 (.0927)	.0770 (.0858)	.0793 (.0873)	.0796 (.0886)	.0769 (.0845)	.0755 (.0832)	- (-)
9c	Light Industry/ Stanley Cohn	.0805 (.0874)	.0685 (.0843)	.0674 (.0833)	.0694 (.0858)	.0695 (.0861)	.0678 (.0844)	- (-)
10a	Construction/ Original Lee	.0224	.0225	.0281	.0255	.0267	.0268	+
10b	Construction/ Modified Lee	.0224 (.0224)	.0225 (.0225)	.0281 (.0281)	.0255 (.0255)	.0267 (.0267)	.0268 (.0268)	+ (+)
10c	Construction/ Stanley Cohn	.0072 (.0072)	.0072 (.0072)	.0088 (.0088)	.0086 (.0086)	.0076 (.0076)	.0071 (.0071)	+ (+)
11a	Transportation and Communication/ Original Lee	.0002	.0002	.0002	.0002	.0002	.0003	o
11b	Transportation and Communication/ Modified Lee	.0002 (.0002)	.0002 (.0002)	.0002 (.0002)	.0002 (.0002)	.0002 (.0002)	.0003 (.0003)	o (o)
11c	Transportation and Communication/ Stanley Cohn	.0003 (.0003)	.0003 (.0003)	.0003 (.0003)	.0004 (.0004)	.0003 (.0003)	.0003 (.0003)	o (o)
12a	Trade and Distribution/ Original Lee	.0055	.0057	.0059	.0063	.0065	.0069	+
12b	Trade and Distribution/ Modified Lee	.0064 (.0063)	.0064 (.0063)	.0066 (.0065)	.0070 (.0069)	.0070 (.0069)	.0074 (.0073)	- (-)
12c	Trade and Distribution/ Stanley Cohn	.0058 (.0058)	.0058 (.0056)	.0058 (.0057)	.0062 (.0060)	.0062 (.0060)	.0060 (.0058)	+ (o)

with respect to the high-durability capital burden ratio for the various estimation techniques considered, so the burden incidence of Soviet NSE does fall upon these remaining sectors. As may be observed, none of the economic sectors in Table 3.18a have avoided the burden incidence of Soviet NSE with respect to the high-durability capital resource.

The middle-durability capital resource in Table 3.18b reflects a sensitivity to the choice of estimation technique for determining the trend of middle-durability capital burden ratio in the following sectors:

- Chemicals (sector 7),
- Light Industry (sector 9), and
- Trade and Distribution (sector 12).

Again, the Light Industry sector is of particular interest. For example, an examination of the entries in Column 9 for Rows 9a, 9b, and 9c of Table 3.18b reveals a sensitivity not only to the general disaggregation rules presented in Table 3.5, but also to the hypothesis with regard to the expenditure pattern for military pay. All of the remaining sectors exhibit a <u>non-decreasing</u> trend with respect to the middle-durability capital burden ratio for all of the estimation techniques considered, so the Soviet NSE burden incidence does fall upon them. However, none of the economic sectors in Table 3.18b has definitely <u>avoided</u> the Soviet NSE burden incidence upon the middle-durability capital resource category for all estimation techniques considered.

In Table 3.18c, the low-durability capital resource does display a <u>non-increasing</u> trend in the sectoral burden ratios for the following sectors that is characteristic of all of the Soviet NSE estimation techniques considered:

- Construction Materials (sector 6),
- Chemicals (sector 7),
- Light Industry (sector 9), and
- Transportation and Communication (sector 11).

So, it may be observed that these four sectors have definitely avoided the burden incidence of Soviet NSE on inventories insofar as the various estimation techniques considered are concerned. However, it may also be observed that the following economic sectors are sensitive to the choice of estimation

techniques and to the hypothesis with respect to the expenditure pattern for military pay from the standpoint of determining the direction of the trend of the low-durability capital burden ratio:

- MBMW (sectors 4 and 5),
- Food (sector 8), and
- Trade and Distribution (sector 12).

All of the remaining sectors in Table 3.18c exhibit a <u>non-decreasing</u> trend in terms of the inventory capital burden ratio for the estimation techniques considered, so the burden incidence of Soviet NSE does fall upon them.

Proceeding now to Tables 3.19a and 3.19b, the fundamental burden incidence pattern occasioned by Soviet NSE for the labor and capital resources are partitioned by qualitative categories as shown. For example, Table 3.19a provides a summary of the trend of the burden ratios in Column 9 of Tables 3.17, 3.18a, 3.18b, and 3.18c for the Soviet labor resource by skill category. The fundamental burden incidence pattern for the labor resource is reflected by the <u>blank</u> entries in Columns 7, 8, and 9 of Table 3.19a for each economic sector and each skill category.[256] The "?" entries in Column 9 indicate those economic sectors and skill categories which are <u>not</u> included in the fundamental burden incidence pattern because the directions of the trends of their burden ratios are sensitive to the choice of estimation technique and to the hypothesis with respect to the expenditure pattern for military pay. On the other hand, the "o" and "-" entries indicate those economic sectors and skill categories which are <u>not</u> included in the fundamental burden incidence pattern because the various estimation techniques considered reveal a "non-increasing" trend with respect to the direction of the burden ratios. Those economic sectors and skill categories with "non-increasing" burden ratio trends for the estimation techniques considered have certainly <u>avoided</u> the burden incidence of Soviet NSE insofar as these skill categories of the labor resource are concerned.

The fundamental burden incidence pattern for the capital resource is reflected by the <u>blank</u> entries in Columns 7, 8, and 9 of Table 3.19b for each economic sector and each durability category. The "?", "o", and "-" entries

[256] In order for a given economic sector and labor skill category to be included in the fundamental burden incidence pattern, a "+" or "*" entry must be present in Columns 4, 5, and 6 of Table 3.19a for all of the estimation techniques considered.

Table 3.19a

The Fundamental Burden Incidence Pattern for the Soviet Labor Resource by Skill Category and Economic Sector (1966-1971) [251]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Total Labor Resource Burden Ratio Trend	High-Skill Labor Resource Burden Ratio Trend	Middle-Skill Labor Resource Burden Ratio Trend	Low-Skill Labor Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Labor Resource		
						High Skill	Middle Skill	Low Skill
1a	Agriculture/ Original Lee	+	+	+	+			
1b	Agriculture/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			
1c	Agriculture/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			
2a	Fuels/ Original Lee	+	+	+	-			-
2b	Fuels/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)			- (-)
2c	Fuels/ Stanley Cohn	+ (+)	+ (+)	+ (+)	- (-)			- (-)
3a	Metals/ Original Lee	+	+	+	+			
3b	Metals/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			
3c	Metals/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			
4&5 a	MBMW/ Original Lee	+	+	+	+			?
4&5 b	MBMW/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			?
4&5 c	MBMW/ Stanley Cohn	+ (+)	+ (+)	+ (+)	- (-)			?

[251] Sources of the data presented in Table 3.19a are as follows:

- *Column* 3 is *taken from Column* 9 *of Table* 3.15.
- Column 4 is taken from Column 9 of Table 3.16a.
- Column 5 is taken from Column 9 of Table 3.16b.
- Column 6 is taken from Column 9 of Table 3.16c.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for <u>all</u> estimating techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern.
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for <u>all</u> estimating techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern.
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for <u>all</u> estimating techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern.
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.19a (continued)

The Fundamental Burden Incidence Pattern for the Soviet Labor Resource by Skill Category and Economic Sector (1966-1971) [251]

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Total Labor Resource Burden Ratio Trend	High-Skill Labor Resource Burden Ratio Trend	Middle-Skill Labor Resource Burden Ratio Trend	Low-Skill Labor Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Labor Resource		
						High Skill	Middle Skill	Low Skill
6a	Construction Materials/ Original Lee	+	o	+	+	o		
6b	Construction Materials/ Modified Lee	+ (+)	- (-)	+ (+)	+ (+)	- (-)		
6c	Construction Materials/ Stanley Cohn	+ (+)	- (-)	+ (+)	+ (+)	- (-)		
7a	Chemicals/ Original Lee	+	+	+	-			-
7b	Chemicals/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)			- (-)
7c	Chemicals/ Stanley Cohn	- (-)	+ (+)	+ (+)	- (-)			- (-)
8a	Food/ Original Lee	+	+	+	o			?
8b	Food/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)			?
8c	Food/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			?
9a	Light Industry/ Original Lee	-	+	+	-			-
9b	Light Industry/ Modified Lee	- (-)	+ (+)	+ (+)	- (-)			- (-)
9c	Light Industry/ Stanley Cohn	- (+)	+ (+)	+ (+)	- (-)			- (-)
10a	Construction/ Original Lee	+	+	+	+	?		?
10b	Construction/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)	?		?
10c	Construction/ Stanley Cohn	+ (+)	o (o)	+ (+)	- (-)	?		?
11a	Transportation and Communication Original Lee	+	+	+	+			?
11b	Transportation and Communication Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			?
11c	Transportation and Communciation Stanley Cohn	+ (+)	+ (+)	+ (+)	o (o)			?
12a	Trade and Distribution/ Original Lee	+	o	+	+	o		
12b	Trade and Distribution/ Modified Lee	+ (+)	o (o)	+ (+)	+ (+)	o (o)		
12c	Trade and Distribution/ Stanley Cohn	+ (+)	o (o)	+ (+)	+ (+)	o (o)		

Table 3.19b

The Fundamental Burden Incidence Pattern for the Soviet Capital Resource by Durability Category and Economic Sector (1966-1971) 252

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Total Labor Resource Burden Ratio Trend	High-Skill Labor Resource Burden Ratio Trend	Middle-Skill Labor Resource Burden Ratio Trend	Low-Skill Labor Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Labor Resource		
						High Durability	Middle Durability	Low Durability
1a	Agriculture/ Original Lee	+	+	+	+			
1b	Agriculture/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			
1c	Agriculture/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			
2a	Fuels/ Original Lee	+	+	+	+			
2b	Fuels/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			
2c	Fuels/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			
3a	Metals/ Original Lee	+	+	+	+			
3b	Metals/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)			
3c	Metals/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)			
4&5 a	MBMW/ Original Lee	+	+	+	+	?		?
4&5 b	MBMW/ Modified Lee	+ (+)	+ (+)	+ (+)	+ (+)	?		?
4&5 c	MBMW/ Stanley Cohn	- (-)	o (o)	+ (+)	- (-)	?		?

252 Sources of the data presented in Table 3.19b are as follows:

- Column 3 is taken from Column 9 of Table 3.17.
- Column 4 is taken from Column 9 of Table 3.18a.
- Column 5 is taken from Column 9 of Table 3.18b.
- Column 6 is taken from Column 9 of Table 3.18c.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for <u>all</u> estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern.
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for <u>all</u> estimation techniques in order to qualify a particular sector for inclusion in the fundamental incidence pattern.
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for <u>all</u> estimation techniques in order to qualify a particular sector for inclusion in the fundamental incidence pattern.
- Entries in this table without parentheses reflect the 64% to 36% hypothesis with respect to expenditures in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.19b (continued)

The Fundamental Burden Incidence Pattern for the Soviet Capital Resource by Durability Category and Economic Sector (1966-1971) 252

1	2	3	4	5	6	7	8	9
Row	Sector/ Estimating Technique	Total Labor Resource Burden Ratio Trend	High-Skill Labor Resource Burden Ratio Trend	Middle-Skill Labor Resource Burden Ratio Trend	Low-Skill Labor Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Labor Resource		
						High Durability	Middle Durability	Low Durability
6a	Construction Materials/ Original Lee	+	+	+	-			-
6b	Construction Materials/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)			- (-)
6c	Construction Materials/ Stanley Conn	* (*)	+ (+)	+ (+)	- (-)			- (-)
7a	Chemicals/ Original Lee	+	+	+	-	?	?	-
7b	Chemicals/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)	?	?	- (-)
7c	Chemicals/ Stanley Conn	- (-)	- (-)	- (-)	- (-)	?	?	- (-)
3a	Food/ Original Lee	+	+	+	-			?
8b	Food/ Modified Lee	+ (+)	+ (+)	+ (+)	- (-)			?
8c	Food/ Stanley Conn	+ (+)	+ (+)	+ (+)	* (-)			?
9a	Light Industry/ Original Lee	-	+	+	-	?	?	-
9b	Light Industry/ Modified Lee	- (-)	- (-)	- (-)	- (-)	?	?	- (-)
9c	Light Industry/ Stanley Conn	- (+)	- (+)	- (+)	- (-)	?	?	- (-)
10a	Construction/ Original Lee	+	+	+	+	?		
10b	Construction/ Original Lee	+ (+)	+ (+)	+ (+)	+ (+)	?		
10c	Construction/ Stanley Conn	* (*)	o (o)	* (*)	* (*)	?		
11a	Transportation and Communication/ Original Lee	+	+	+	o	?		o
11b	Transportation and Communication/ Modified Lee	+ (+)	+ (+)	+ (+)	o (o)	?		o (o)
11c	Transportation and Communication/ Stanley Conn	* (*)	o (o)	* (*)	o (o)	?		o (o)
12a	Trade and Distribution/ Original Lee	-	+	+	-		?	?
12b	Trade and Distribution/ Modified Lee	+ (+)	+ (+)	+ (+)	- (+)		?	?
12c	Trade and Distribution/ Stanley Conn	o (o)	+ (*)	o (o)	+ (o)		?	?

denote those economic sectors and durability categories that are not included in the fundamental burden incidence pattern for the following reasons:

- The "?" entries are not included because the directions of the trends of their burden ratios are dependent upon the choice of estimation techniques and the hypothesis with respect to the expenditure pattern for military pay.
- The "o" and "-" entries are not included because those economic sectors and durability categories with "non-increasing" trends with respect to the economic burden ratios for the various estimation techniques considered have avoided the Soviet NSE burden incidence on those capital resource durability categories.

A sensitivity analysis for the fundamental burden incidence pattern of Soviet resource allocation associated with each baseline estimation methodology is presented in Table 2.2. The three proposed changes in the experimental conditions may be summarized as follows:

- A change in the assumption that "all technological progress appears in the final demand where fewer inputs are required over time to obtain a unit of final product";
- Elimination of the special sectoral pattern of RDT&E expenditures from the estimates of Soviet NSE by sector; and
- A test of the importance of performing the burden ratio computations with input-output data in producer's prices instead of in purchaser's prices.

Inasmuch as these three changes may be imposed one at a time, two at a time, or all three simultaneously, then Table 3.20 actually defines eight alternative experimental designs, which may be identified as follows:[257]

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[257] The eight experimental conditions [i.e., $2^3 = \binom{3}{0} + \binom{3}{1} + \binom{3}{2} + \binom{3}{3} = 1+3+3+1=8$] are also defined in Table B-35 of Appendix B. One experimental design [i.e., $\binom{3}{0} = 1$] corresponds to Tables 3.19a and 3.19b; three experimental designs [i.e., $\binom{3}{1} = 3$] correspond to the three changes being imposed one at a time; three experimental designs [i.e., $\binom{3}{2} = 3$] correspond to the three changes being imposed two at a time; and one experimental design [i.e., $\binom{3}{3} = 1$] corresponds to all three changes being imposed simultaneously.

- The fundamental burden incidence pattern in Tables 3.19a and 3.19b corresponds to Experimental Design No. 1 in Table 3.20;
- The three changes that are imposed one at a time correspond to Experimental Design Nos. 2, 3, and 5 in Table 3.20, and the associated fundamental burden incidence patterns are summarized in Tables 3.21a and 3.21b;
- The three changes that are imposed two at a time correspond to Exerpimental Design Nos. 4, 6, and 7 in Table 3.20, and the associated fundamental burden incidence patterns are summarized in Tables 3.22a and 3.22b; and
- The three changes that are imposed simultaneously correspond to Experimental Design No. 8 in Table 3.20, and the associated fundamental burden incidence pattern is summarized in Tables 3.23a and 3.23b.

Inasmuch as Tables 3.21, 3.22 and 3.23 include the eight types of resources by sector defined in Table B-36 of Appendix B, then the results of the 64 different experiments performed may be described in terms of <u>changes</u> in the fundamental burden incidence patterns compared to Table 3.19.[258]

Table 3.20
Eight Basic Experimental Designs for Estimating the Soviet Economic Burden Ratios Associated with a Given Baseline Methodology for Estimating Soviet NSE

Control Condition / Experimental Design No. and Table		1		2		3	
		1st Experimental Condition		2nd Experimental Condition		3rd Experimental Condition	
		Technological Progress		RDT&E Expenditures		Leontief Inverse [259]	
		With	Without	Including	Excluding	With Producer's Prices	Without Producer's Prices
1	3.19	X		X		X	
2	3.21	X			X	X	
3	3.21		X	X		X	
4	3.22		X		X	X	
5	3.21	X		X			X
6	3.22	X			X		X
7	3.22		X	X			X
8	3.23		X		X		X

[258] Inasmuch as the computations in Tables 3.15, 3.16a, 3.16b, 3.16c, 3.17, 3.18a, 3.18b, and 3.18c must be performed for each of the eight experimental designs in Table 3.20, the combinations constitute the 64 different experiments performed.

[259] "Without Producer's Prices" means that the Leontief Inverse in Purchaser's Prices in Table B-34 of Appendix B <u>replaces</u> the Leontief Inverse in Producer's Prices in Table B-1 in the same appendix.

Table 3.21a reflects the directions of the trends of the economic burden ratios for the Soviet labor resource by skill categories for:

- Each of the twelve economic sectors,
- One of the three experimental conditions considered, and
- Experimental Designs Nos. 2, 3, and 5.[260]

Since Experimental Design No. 2 excludes only RDT&E expenditures, then the corresponding fundamental burden incidence pattern in Table 3.21a may be compared to the original fundamental burden incidence pattern in Table 3.18a. As may be observed, the Food sector appears to be the most sensitive to the exclusion of RDT&E expenditures, because the low-skill labor category definitely avoids the burden incidence of Soviet NSE when this particular experimental condition is changed. Although Experimental Design No. 3 eliminates only the adjustment for technological progress productivity, the corresponding fundamental burden incidence pattern in Table 3.21a is drastically altered when compared to the original fundamental burden incidence pattern in Table 3.18a. When the adjustment for technological progress productivity is eliminated, then all economic sectors and all labor skill categories will absorb the burden incidence of Soviet defense spending.[261] Finally, Experimental Design No. 5 changes the Leontief inverse used in the burden ratio computations from producer's prices in Table B-1 of Appendix B to purchaser's prices in Table B-34. Generally speaking, it is much easier to obtain input-output (I/O) data in purchaser's prices and then perform the preliminary computations and analyses. Only later does the "theoretically" more appropriate input-output data in producer's prices become available which conform with other data in the Soviet statistical handbook N.Kh. Then, the preliminary computations are revised. However, the fundamental burden incidence pattern corresponding to Experimental Design No. 5 in Table 3.21a does not

[260] The sensitivity analysis experiments in Tables 3.21, 3.22, and 3.23 have only been performed with Bill Lee's original estimation technique and that of Stanley Cohn. A more complete sensitivity analysis will require the use of Bill Lee's modified technique and the CIA direct costing estimation technique.

[261] Actually, the Fuels, Contruction Materials, and Trade and Distribution sectors have "?" entries for Experimental Design No. 3 which indicates some sensitivity to the choice of estimation technique or to the hypothesis with regard to the expenditure pattern for military pay. Elimination of the productivity for technological progress in Experimental Design No. 3 corresponds to the substitution of Equation B-27 into Equation B-16, which is used in Equations B-17, B-18, B-19 and B-21.

Table 3.21a

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Labor Resource (by Skill Category and Economic Sector) to Changes in One of Three Experimental Conditions (1966-1971) [262]

1	2	3			4			5			6			7			8			9		
Row	Sector and Estimation Technique	Total Labor Resource Burden Ratio Trend Experimental Design			High-Skill Labor Resource Burden Ratio Trend Experimental Design			Middle-Skill Labor Resource Burden Ratio Trend Experimental Design			Low-Skill Labor Resource Burden Ratio Trend Experimental Design			Fundamental Burden Incidence Pattern for the Soviet Labor Resource: High-Skill Experimental Design			Middle-Skill Experimental Design			Low-Skill Experimental Design		
		2	3	5	2	3	5	2	3	5	2	3	5	2	3	5	2	3	5	2	3	5
1a	Agriculture/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
1c	Agriculture/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)									
2a	Fuels/ Original Lee	+	+	+	+	+	+	+	+	+	-	+	o							-	?	o
2c	Fuels/ Stanley Cohn	- (-)	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	- (-)	- (-)							- (-)	?	- (-)
3a	Metals/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
3c	Metals/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)									
4&5 a	MBMW/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+							?		?
4&5 c	MBMW/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	- (-)							?		?
6a	Construction Materials/ Original Lee	+	+	+	-	+	o	+	+	+	+	+	+	-	?	o				?		?
6c	Construction Materials/ Stanley Cohn	- (-)	+ (+)	- (*)	- (-)	o (+)	- (-)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	- (-)	- (-)	?	- (-)				?		?
7a	Chemicals/ Original Lee	+	+	+	+	+	+	+	+	+	-	+	-							-		-
7c	Chemicals/ Stanley Cohn	- (-)	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	- (-)							- (-)		- (-)
8a	Food/ Original Lee	+	+	+	+	+	+	+	+	+	-	+	o							-		?
8c	Food/ Stanley Cohn	o (o)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	+ (+)							- (-)		?
9a	Light Industry/ Original Lee	-	+	-	+	+	+	+	+	+	-	+	-							-		-
9c	Light Industry/ Stanley Cohn	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	- (-)							- (-)		- (-)
10a	Construction/ Original Lee	-	+	+	o	+	+	+	+	+	+	+	+	?						?		?
10c	Construction/ Stanley Cohn	- (-)	+ (+)	- (-)	- (*)	+ (+)	* (*)	+ (+)	+ (+)	+ (+)	- (-)	* (*)	- (-)	?						?		?
11a	Transportation and Communication/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+							?		?
11c	Transportation and Communication/ Stanley Cohn	- (-)	+ (+)	* (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	- (-)							?		?
12a	Trade and Distribution/ Original Lee	+	+	+	o	o	o	+	+	+	+	+	+	o	?	o	?			?		?
12c	Trade and Distribution/ Stanley Cohn	- (-)	+ (+)	+ (-)	o (o)	- (*)	o (o)	o (+)	+ (+)	+ (+)	- (-)	+ (+)	* (-)	o (o)	,	o (o)	?			?		?

262 Sources of the data presented in Table 3.21a are as follows:

- Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout that resembles Column 9 of Tables 3.5, 3.16a, 3.16b, and 3.16c. However, instead of Experimental Design No. 1, the experimental conditions were changed as indicated in Table 3.20 to define Experimental Design Nos. 2, 3, and 5, respectively. A copy of this computer printout is available upon request.
- *Column 7* is taken from *Column 4*; a "non-decreasing" burden ratio trend is required for all estimating techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- *Column 8* is taken from *Column 5*; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- *Column 9* is taken from *Column 6*; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table *without parentheses* reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

show that much change occurs when compared to the original fundamental burden incidence pattern in Table 3.21a. The same sectors which originally avoided the burden incidence of Soviet defense spending are unchanged by the experimental condition in Experimental Design No. 5. Consequently, in the case of the Soviet labor resource, when only one of the three experimental conditions are changed at a time, then the original fundamental burden incidence pattern is the most sensitive to the elimination of the productivity adjustment for technological progress (i.e., Experimental Design No. 3). On the other hand, it is the least sensitive to whether the Leontief Inverse is expressed in producer's prices or in purchaser's prices. The inclusion or exclusion of RDT&E expenditures has a moderate impact on the original fundamental burden incidence pattern.

Table 3.22a reflects the directions of the trends of the economic burden ratios for the Soviet labor resource by skill categories for:

- Each of the twelve economic sectors,
- Two of the three experimental conditions considered, and
- Experimental Designs Nos. 4, 6, and 7.

Since Experimental Design No. 4 is equivalent to the imposition of both Experimental Designs Nos. 2 and 3 simultaneously (i.e., excluding RDT&E expenditures and eliminating the adjustment for technological progress productivity), then the most important experimental condition should dominate the fundamental burden incidence pattern in Table 3.22a. Consequently, the results of Experimental Design No. 4 are very similar to those in Experimental Design No. 3 due to the dominant influence that the productivity adjustment for technological progress has upon changing the original fundamental burden incidence pattern in Table 3.19a. Next, since Experimental Design No. 6 is equivalent to the imposition of both Experimental Designs Nos. 2 and 5 simultaneously (i.e., excluding RDT&E expenditures and using a Leontief inverse in purchaser's prices), then there is not much change from the original fundamental burden incidence pattern in Table 3.19a. This situation reflects the much milder impact that the RDT&E expenditures and the Leontief inverse in purchaser's prices (as experimental conditions) have upon the fundamental burden incidence pattern in Experimental Design No. 6 of Table 3.19a. Finally, Experimental Design No. 7 is equivalent to the imposition of both Experimental Designs Nos. 3 and 5 simultaneously (i.e., eliminating the productivity adjustment for technological progress and using a Leontief inverse

Table 3.22a

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Labor Resource (by Skill Category and Economic Sector) to Changes in Two of Three Experimental Conditions (1966-1971) [263]

1	2	3			4			5			6			7			8			9		
Row	Sector and Estimation Technique	Total Labor Resource Burden Ratio Trend — Experimental Design			High-Skill Labor Resource Burden Ratio Trend — Experimental Design			Middle-Skill Labor Resource Burden Ratio Trend — Experimental Design			Low-Skill Labor Resource Burden Ratio Trend — Experimental Design			Fundamental Burden Incidence Pattern for the Soviet Labor Resource: High-Skill Experimental Design			Middle-Skill Experimental Design			Low-Skill Experimental Design		
		4	6	7	4	6	7	4	6	7	4	6	7	4	6	7	4	6	7	4	6	7
1a	Agriculture/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
1c	Agriculture/ Stanley Conn	+ (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)									
2a	Fuels/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+							?	?	?
2c	Fuels/ Stanley Conn	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	- (-)	- (-)							?	?	?
3a	Metals/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
3c	Metals/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)									
4&5 a	MBMW/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+								?	
4&5 c	MBMW/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)	- (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								?	
6a	Construction Materials/ Original Lee	+	+	+	+	-	+	+	+	+	+	+	+	?	-	?					?	
6c	Construction Materials/ Stanley Conn	+ (+)	- (-)	+ (+)	o (+)	- (-)	o (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	?	- (-)	?					?	
7a	Chemicals/ Original Lee	+	+	+	+	+	+	+	+	+	+	-	+								-	
7c	Chemicals/ Stanley Conn	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								- (-)	
8a	Food/ Original Lee	+	+	+	+	+	+	+	+	+	+	-	+								-	
8c	Food/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								- (-)	
9a	Light Industry/ Original Lee	+	-	+	+	+	+	+	+	+	+	-	+								-	
9c	Light Industry/ Stanley Conn	+ (-)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								- (-)	
10a	Construction/ Original Lee	+	-	+	+	+	+	+	+	+	+	-	+								-	
10c	Construction/ Stanley Conn	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								- (-)	
11a	Transportation and Communication/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+								?	
11c	Transportation and Communication/ Stanley Conn	+ (+)	+ (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)								?	
12a	Trade and Distribution/ Original Lee	+	+	+	o	o	o	+	+	+	+	+	+	o	o	o					?	
12c	Trade and Distribution/ Stanley Conn	+ (+)	+ (-)	+ (+)	o (o)	o (o)	o (o)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	+ (+)	o (o)	o (o)	o (o)					?	

263 Sources of the data presented in Table 3.22a are as follows:

- Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout that resembles Column 9 of Tables 3.5, 3.16a, 3.16b, and 3.16c. However, instead of Experimental Design No. 1, the experimental conditions have been changed as indicated in Table 3.20 to define Experimental Design Nos. 4, 6, and 7, respectively. A copy of this computer printout is available upon request.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

in purchaser's prices). Of course, in view of the dominant influence that the productivity adjustment for technological progress has upon changing the original fundamental burden incidence pattern in Table 3.19a, the results of Experimental Design No. 7 are very similar to those of Experimental Design No. 3.

Table 3.23a reflects the directions of the trends of the economic burden ratios for the Soviet labor resource by skill categories for:

- Each of the twelve economic sectors,
- All of the three experimental conditions considered, and
- Experimental Design No. 8.

Inasmuch as Experimental Design No. 8 corresponds to the imposition of all three experimental conditions simultaneously, then a comparison of Table 3.19a and Table 3.23a reflects the total impact upon the fundamental burden incidence pattern. Since the number of blank entries for sectors in Columns 7, 8, and 9 of Table 3.23a exceeds the number of blank entries for sectors in Columns 7, 8, and 9 of Table 3.19a, then the total impact of the three experimental conditions is to increase the fundamental burden incidence pattern for the labor resource associated with Soviet NSE. By contrast, with respect to the capital resource, a comparison of Table 3.19b and Table 3.23b indicates that the number of blank entries for sectors in Columns 7, 8, and 9 are exactly equal. However, the distribution of the fundamental burden incidence pattern among the twelve economic sectors and the three durability categories has definitely changed as a result of the total impact of the three experimental conditions. This dramatic difference in the total impact upon the fundamental burden incidence pattern associated with Soviet NSE (which the three experimental conditions have upon the capital resource), in contrast to the labor resource, warrants closer examination.

Table 3.21b reflects the directions of the trends of the economic burden ratios for the Soviet capital resource by durability categories for each of the twelve sectors and two of the three estimation techniques considered for Experimental Designs Nos. 2, 3, and 5. Excluding only RDT&E expenditures, Experimental Design No. 2 in Table 3.21b reveals a change among sectors and durability categories when compared to the original fundamental burden incidence

Table 3.23a

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Labor Resource (by Skill Category and Economic Sector) to Simultaneous Changes in All of Three Experimental Conditions (1966-1971)[264]

1	2	3	4	5	6	7	8	9
Row	Sector and Estimation Technique	Total Labor Resource Burden Ratio Trend	High-Skill Labor Resource Burden Ratio Trend	Middle-Skill Labor Resource Burden Ratio Trend	Low-Skill Labor Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Labor Resource: High-Skill	Middle-Skill	Low-Skill
		Experimental Design 3	Experimental Design 3	Experimental Design 3	Experimental Design 3	Experimental Design 3	Experimental Design 3	Experimental Design 3
1a	Agriculture/ Original Lee	+	+	+	+			
1c	Agriculture/ Stanley Conn	+ (+)	+ (+)	+ (+)	- (+)			
2a	Fuels/ Original Lee	+	+	+	+			?
2c	Fuels/ Stanley Conn	+ (+)	+ (+)	+ (+)	- (-)			?
3a	Metals/ Original Lee	+	+	+	+			
3c	Metals/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
4&5 a	MBMW/ Original Lee	+	+	+	+			
4&5 c	MBMW/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
6a	Construction Materials/ Original Lee	+	+	+	+			
6c	Construction Materials/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
7a	Chemicals/ Original Lee	+	+	+	+			
7c	Chemicals/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
8a	Food/ Original Lee	+	+	+	+			
8c	Food/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
9a	Light Industry/ Original Lee	+	+	+	+			
9c	Light Industry/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
10a	Construction/ Original Lee	+	+	+	+			
10c	Construction/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
11a	Transportation and Communication/ Original Lee	+	+	+	+			
11c	Transportation and Communication/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
12a	Trade and Distribution/ Original Lee	+	o	+	+	o		
12c	Trade and Distribution/ Stanley Conn	+ (+)	o (o)	+ (+)	+ (+)	o (o)		

264 Sources of the data presented in Table 3.23a are as follows:

- *Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout* that resembles Column 9 of Tables 3.15, 3.16a, 3.16b, and 3.16c. However, instead of Experimental Design No. 1, the experimental conditions have been changed as indicated in Table 3.20 to define Experimental Design No. 8. A copy of this computer printout is available upon request.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.23b

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Capital Resource (by Durability Category and Economic Sector) to Simultaneous Changes in All of Three Experimental Conditions (1966-1971)[265]

1	2	3	4	5	6	7	8	9
Row	Sector and Estimation Technique	Total Capital Resource Burden Ratio Trend	High-Durability Capital Resource Burden Ratio Trend	Middle-Durability Capital Resource Burden Ratio Trend	Low-Durability Capital Resource Burden Ratio Trend	Fundamental Burden Incidence Pattern for the Soviet Capital Resource: High-Durability	Middle-Durability	Low-Durability
		Experimental Design 8	Experimental Design 8	Experimental Design 8	Experimental Design 8	Experimental Design 8	Experimental Design 8	Experimental Design 8
1a	Agriculture/ Original Lee	-	-	-	-	-	-	
1c	Agriculture/ Stanley Conn	- (-)	- (-)	- (-)	+ (+)	- (-)	- (-)	
2a	Fuels/ Original Lee	+	+	+	+	?	?	
2c	Fuels/ Stanley Conn	- (-)	- (-)	- (-)	+ (+)	?	?	
3a	Metals/ Original Lee	+	+	+	+			
3c	Metals/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
4&5 a	MBMW/ Original Lee	+	+	+	+			
4&5 c	MBMW/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)			
6a	Construction Materials/ Original Lee	+	+	+	-			-
6c	Construction Materials/ Stanley Conn	+ (+)	+ (+)	+ (+)	- (-)			- (-)
7a	Chemicals/ Original Lee	+	+	+	o			o
7c	Chemicals/ Stanley Conn	+ (-)	+ (+)	+ (+)	- (-)			- (-)
8a	Food/ Original Lee	+	+	+	-			-
8c	Food/ Stanley Conn	+ (+)	+ (+)	+ (+)	- (-)			- (-)
9a	Light Industry/ Original Lee	-	-	+	-	?	?	-
9c	Light Industry/ Stanley Conn	- (-)	+ (-)	+ (-)	- (-)	?	?	- (-)
10a	Construction/ Original Lee	-	-	+	-	-	?	-
10c	Construction/ Stanley Conn	- (-)	- (-)	- (-)	- (-)	- (-)	?	- (-)
11a	Transportation and Communication/ Original Lee	+	+	+	-	?		
11c	Transportation and Communication/ Stanley Conn	+ (+)	+ (-)	+ (+)	+ (+)	?		
12a	Trade and Distribution/ Original Lee	+	+	-	+		?	
12c	Trade and Distribution/ Stanley Conn	+ (+)	+ (+)	o (o)	+ (+)		?	

[265] Sources of the data presented in Table 3.23b are as follows:

- Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout that resembles Column 9 of Tables 3.17, 3.18a, 3.18b, and 3.18c. However, instead of Experimental Design No. 1, the experimental conditions have been changed as indicated in Table 3.20 to define Experimental Design No. 8. A copy of this computer printout is available upon request.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Table 3.21b

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Capital Resource (by Durability Category and Economic Sector) to Changes in One of Three Experimental Conditions (1966-1971) [266]

1	2	3			4			5			6			7			8			9		
Row	Sector and Estimation Technique	Total Capital Resource Burden Ratio Trend — Experimental Design			High-Durability Capital Resource Burden Ratio Trend — Experimental Design			Middle-Durability Capital Resource Burden Ratio Trend — Experimental Design			Low-Durability Capital Resource Burden Ratio Trend — Experimental Design			Fundamental Burden Incidence Pattern for the Soviet Capital Resource: High-Durability — Experimental Design			Middle-Durability — Experimental Design			Low-Durability — Experimental Design		
		2	3	5	2	3	5	2	3	5	2	3	5	2	3	5	2	3	5	2	3	5
1a	Agriculture/ Original Lee	+	-	+	+	-	+	+	-	+	-	+	+		-			-				
1c	Agriculture/ Stanley Conn	+ (+)	+ (-)	+ (+)	+ (+)	- (-)	+ (+)	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	+ (+)		- (-)			- (-)				
2a	Fuels/ Original Lee	+	+	+	+	+	+	+	+	-	+	+	+	?	?	?	?	?	?			
2c	Fuels/ Stanley Conn	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	+ (+)	+ (+)	+ (+)	?	?	?	?	?	?			
3a	Metals/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
3c	Metals/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (-)									
4&5 a	MBMW/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	-							?		
4&5 c	MBMW/ Stanley Conn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (+)	- (-)	+ (+)	+ (+)							?		
6a	Construction Materials/ Original Lee	+	+	+	+	+	+	+	+	+	-	-	-							-	-	-
6c	Construction Materials/ Stanley Conn	- (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (-)	- (-)	- (-)	- (-)							- (-)	- (-)	- (-)
7a	Chemicals/ Original Lee	+	+	+	+	+	+	+	+	+	-	+	-	?	?	?	?	?	?	-	?	-
7c	Chemicals/ Stanley Conn	- (-)	- (-)	- (-)	- (-)	o (-)	- (-)	- (-)	- (o)	- (-)	- (-)	- (-)	- (-)	?	?	?	?	?	?	- (-)	?	- (-)
8a	Food/ Original Lee	+	+	+	+	+	+	+	+	+	-	-	-						?	-	?	?
8c	Food/ Stanley Conn	o (o)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (-)	- (-)	+ (-)	+ (-)						?	- (-)	?	?
9a	Light Industry/ Original Lee	-	-	-	-	o	o	+	+	+	-	-	-	-	?	?	?	?	?	?	-	-
9c	Light Industry/ Stanley Conn	- (-)	- (-)	- (+)	- (-)	- (+)	- (+)	+ (-)	- (+)	- (+)	+ (-)	- (-)	- (-)	- (-)	?	?	?	?	?	?	- (-)	- (-)
10a	Construction/ Original Lee	-	-	+	+	-	-	-	-	+	+	+	+	?	-	?	-	-	?		?	
10c	Construction/ Stanley Conn	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	+ (+)	- (-)	+ (+)	?	- (-)	?	- (-)	- (-)	?		?	
11a	Transportation and Communication/ Original Lee	+	+	+	+	+	+	+	+	+	+	o	+	?	?	?	?		?		?	
11c	Transportation and Communication/ Stanley Conn	- (-)	- (-)	+ (-)	+ (-)	- (+)	+ (-)	+ (-)	+ (+)	- (+)	+ (+)	o (+)	+ (+)	?	?	?	?		?		?	
12a	Trade and Distribution/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	-	?	?	?	?	?	?	?		
12c	Trade and Distribution/ Stanley Conn	- (o)	+ (o)	+ (o)	o (+)	o (+)	o (+)	o (o)	o (o)	o (o)	o (+)	+ (+)	+ (+)	?	?	?	?	?	?	?		

[266] Sources of the data presented in Table 3.21b are as follows:

- Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout that resembles Column 9 of Tables 3.17, 3.18a, 3.18b, and 3.18c. However, instead of Experimental Design No. 1, the experimental conditions have been changed as indicated in Table 3.20 to define Experimental Design Nos. 2, 3, and 5, respectively. A copy of the computer printout is available upon request.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 54% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

pattern in Table 3.19b. For example, the Food sector inventories do not appear to have been affected by the burden incidence of Soviet NSE, but the inventories of the Transportation and Communication sector appear to have absorbed the burden incidence as a result of excluding RDT&E expenditures. In addition, the low durability category for the Light Industry sector, which was not affected by the capital burden incidence in Table 3.19b, now shifts to the high durability category for this same sector which avoids the capital burden incidence in Table 3.21b when the experimental condition is changed to Design No. 2. Experimental Design No. 3, which eliminates only the productivity adjustment for technological progess , causes a reduction in the burden incidence of Soviet NSE on high and middle-durability categories of the capital resource in the Agricultural sector and Construction sectors. Therefore, in sharp contrast to the labor resource, Experimental Design No. 3 for the capital resource results in a reduction in the fundamental burden incidence pattern of Soviet NSE rather than in an increase. Finally, Experimental Design No. 5, which changes only the Leontief inverse used in the burden ratio computations from producer's prices in Table B-1 of Appendix B to purchaser's prices in Table B-34, reflects a slight increase in the fundamental burden incidence pattern because the inventories of the Transportation and Communication sector appear to have absorbed the burden of Soviet defense spending. This slight distortion in the trends of the estimated burden ratios, which is a result of not using the theoretically more appropriate Leontief inverse in producer's prices, does not appear to invalidate preliminary computations and analyses performed with input-output data in purchaser's prices. Consequently, in the case of the Soviet capital resource when only one of the three experimental conditions is changed at a time, the distribution of the original fundamental burden incidence pattern among economic sectors and durability categories is the most sensitive to the elimination of RDT&E expenditures (i.e., Experimental Design No. 2). On the other hand, the intensity of the original fundamental burden incidence pattern, as reflected in the number of blank entries for sectors in Columns 7, 8, and 9 in Table 3.19b, is the most sensitive to the elimination of the productivity adjustment for technological progress (i.e., Experimental Design No. 3). Again, it is the least sensitive to whether the Leontief Inverse is expressed in producer's prices or in purchaser's prices (i.e., Experimental Design No. 5).

Table 3.22b reflects the directions of the trends of the economic burden ratio for the Soviet capital resource by durability categories for each of the twelve sectors and two of the three estimation techniques considered for Experimental Designs Nos. 4, 6, and 7. Inasmuch as Experimental Design No. 4 corresponds to imposing Experimental Designs Nos. 2 and 3 simultaneously, then the distribution and the intensity of the original fundamental burden incidence pattern are both influenced by excluding RDT&E expenditures and eliminating the productivity adjustment for technological progress simultaneously. In the case of Experimental Design No. 4, one indication of this impact is that only thirteen blank entries for sectors remain in Columns 7, 8, and 9 of Table 3.22b by contrast with 15 and 14 blank entries in Columns 7, 8, and 9 of Table 3.21b for Experimental Designs Nos. 2 and 3, respectively. Next, inasmuch as Experimental Design No. 6 corresponds to imposing Experimental Designs Nos. 2 and 5 simultaneously, then only the distribution of the original fundamental burden incidence pattern is substantially changed. As a result, Experimental Design No. 6 closely resembles Experimental Design No. 2 insofar as its resource allocation effects upon the capital resource associated with Soviet defense spending are concerned. Finally, since Experimental Design No. 7 corresponds to imposing Experimental Designs Nos. 3 and 5 simultaneously, then only the intensity of the original fundamental burden incidence pattern is substantially changed. Therefore, as a result, Experimental Design No. 7 closely resembles Experimental Design No. 3 insofar as its resource allocation effects on the capital resource associated with Soviet defense spending are concerned. By contrast with the labor resource, the changes in experimental conditions involving RDT&E expenditures, as well as the productivity adjustment for technological progress both have a dominant influence upon changing the original fundamental burden incidence pattern in Table 3.19b. However, the nature of this influence is different because the change in RDT&E expenditures largely influences the distribution of the original fundamental burden incidence pattern among economic sectors and durability categories. On the other hand, the change in the productivity adjustment for technological progress largely influences the intensity of the original fundamental burden incidence pattern. As was the case with the labor resource, the capital resource is the least sensitive to whether the Leontief Inverse is expressed in producer's prices or in purchaser's prices.

Table 3.22b

Sensitivity of the Fundamental Burden Incidence Pattern for the Soviet Capital Resource (by Durability Category and Economic Sector) to Changes in Two of Three Experimental Conditions (1966-1971)[267]

1	2	3			4			5			6			7			8			9		
Row	Sector and Estimation Technique	Total Capital Resource Burden Ratio Trend Experimental Design			High-Durability Capital Resource Burden Ratio Trend Experimental Design			Middle-Durability Capital Resource Burden Ratio Trend Experimental Design			Low-Durability Capital Resource Burden Ratio Trend Experimental Design			Fundamental Burden Incidence Pattern for the Soviet Capital Resource: High-Durability Experimental Design			Middle-Durability Experimental Design			Low-Durability Experimental Design		
		4	6	7	4	6	7	4	6	7	4	6	7	4	6	7	4	6	7	4	6	7
1a	Agriculture/ Original Lee	-	+	-	-	+	-	-	+	-	+	+	+	-		?	-		-			
1c	Agriculture/ Stanley Cohn	- (-)	+ (+)	+ (-)	- (-)	+ (+)	+ (-)	- (-)	+ (+)	- (-)	+ (+)	+ (+)	+ (+)	- (-)		?	- (-)		- (-)			
2a	Fuels/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+	?	?	?	?	?	?			
2c	Fuels/ Stanley Cohn	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	+ (+)	+ (+)	+ (+)	?	?	?	?	?	?			
3a	Metals/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+									
3c	Metals/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)									
4&5 a	MBMW/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+								?	
4&5 c	MBMW/ Stanley Cohn	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (*)	+ (+)								?	
6a	Construction Materials/ Original Lee	+	+	+	+	+	+	+	+	+	-	-	-							-	-	-
6c	Construction Materials/ Stanley Cohn	+ (+)	+ (-)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	- (-)	- (-)							- (-)	- (-)	- (-)
7a	Chemicals/ Original Lee	+	+	+	+	+	+	+	+	+	o	-	+	?	?	?	?	?	?	o	-	?
7c	Chemicals/ Stanley Cohn	- (-)	- (-)	- (-)	o (-)	- (-)	- (*)	o (-)	- (-)	- (*)	- (-)	- (-)	- (-)	?	?	?	?	?	?	- (-)	- (-)	?
8a	Food/ Original Lee	+	+	+	+	+	+	+	+	+	-	-	-							-	-	?
8c	Food/ Stanley Cohn	+ (+)	o (*)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	- (-)	- (-)	+ (-)							- (-)	- (-)	?
9a	Light Industry/ Original Lee	-	-	-	-	-	+	+	+	+	-	-	-	-	?	?	?	?	?	-	-	-
9c	Light Industry/ Stanley Cohn	- (-)	- (-)	- (-)	- (-)	+ (-)	- (+)	- (-)	+ (-)	- (+)	- (-)	- (-)	- (-)	- (-)	?	?	?	?	?	- (-)	- (-)	- (-)
10a	Construction/ Original Lee	-	-	-	-	+	-	-	+	-	+	+	+	-	?	-	-	?	-	?		?
10c	Construction/ Stanley Cohn	- (-)	- (-)	- (-)	- (-)	+ (-)	- (-)	- (-)	- (-)	- (-)	- (-)	+ (*)	- (-)	- (-)	?	- (-)	- (-)	?	- (-)	?		?
11a	Transportation and Communication/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+	?	?		?	?				
11c	Transportation and Communication/ Stanley Cohn	+ (-)	+ (-)	+ (*)	- (*)	+ (-)	+ (*)	- (*)	- (-)	+ (*)	+ (+)	+ (+)	+ (+)	?	?		?	?				
12a	Trade and Distribution/ Original Lee	+	+	+	+	+	+	+	+	+	+	+	+	?	?		?	?	?	?	?	
12c	Trade and Distribution/ Stanley Cohn	- (o)	o (o)	+ (o)	o (*)	o (*)	+ (*)	o (o)	o (o)	o (o)	o (*)	o (*)	+ (*)	?	?		?	?	?	?	?	

267 Sources of the data presented in Table 3.22b are as follows:

- Columns 3, 4, 5, and 6 are taken from a GE-TEMPO computer printout that resembles Column 9 of Tables 3.17, 3.18a, 3.18b, and 3.18c. However, instead of Experimental Design No. 1, the experimental conditions have been changed as indicated in Table 3.20 to define Experimental Design Nos. 4, 6, and 7, respectively. A copy of this computer printout is available upon request.
- Column 7 is taken from Column 4; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

The rankings of the various economic sectors in terms of their "relative sensitivities" to the changes in the experimental conditions identified in Table 3.20 may be summarized as follows:[268]

- Very Sensitive
  - Labor Resource: Construction Materials (sector 6) and Trade and Distribution (sector 12).
  - Capital Resource: Agriculture (sector 1), Light Industry (sector 9), and Construction (sector 10).
- Moderately Sensitive
  - Labor Resource: Fuels (sector 2), Chemicals (sector 7), Food (sector 8), Light Industry (sector 9), and Construction (sector 10).
  - Capital Resource: Construction Materials (sector 6), Chemicals (sector 7), and Food (sector 8).
- Slightly Sensitive
  - Labor Resource: MBMW (sectors 4 and 5) and Transportation and Communication (sector 11).
  - Capital Resource: Fuels (sector 2), MBMW (sectors 4 and 5), Transportation and Communication (sector 11), and Trade and Distribution (sector 12).
- Insensitive
  - Labor Resource: Agriculture (sector 1) and Metals (sector 3).
  - Capital Resource: Metals (sector 3).

This ranking of relative sensitivities provides a basis for the following preliminary conclusions with regard to resource allocation to those economic sectors which appear to have absorbed the greatest impact of increased Soviet defense spending during the period 1966-1971.

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[268] The "very sensitive" category reflects a non-increasing trend with respect to the burden ratio in more than one resource category for all of the estimation techniques considered. The "moderately sensitive" category reflects a non-increasing trend with respect to the burden ratio in at least one resource category for all of the estimation techniques considered. The "slightly sensitive" category reflects a non-increasing trend with respect to the burden ratio in at least one resource category for some, but not all, estimation techniques considered. The "insensitive" category reflects an increasing trend with respect to the burden ratio for all of the resource categories and for all of the estimation techniques considered.

- The Metals sector exhibits an increasing trend with respect to the burden ratio for all of the estimation techniques considered and all skill, as well as durability, categories. Therefore, the Metals sector, which is characterized as "insensitive" with reference to the labor and capital resources, definitely absorbs the burden of increased Soviet NSE.

- The MBMW sectors, as well as the Transportation and Communication sector, are characterized as "slightly sensitive" with reference to the labor and capital resources. Consequently, these three sectors probably absorb the burden of increased Soviet NSE during the period 1966-1971.

- All of the remaining sectors are characterized as "very sensitive" or "moderately sensitive" with reference to either the labor or the capital resource or for both resources. Therefore, at least one or more of the skill categories or the durability categories have definitely avoided the burden of increased Soviet defense spending for all of the estimation techniques considered and for one or more of the experimental conditions defined in Table 3.20.

Of course, these preliminary conclusions are subject to revision when additional baseline estimating techniques are considered and the sectoral disaggregation of the respective numerical estimates is accomplished by means of the general rules summarized in Table 3.5.

To conclude this section on the "ex post" resource allocation analysis of the estimated sectoral composition of Soviet defense spending, a recently announced procedure for applying the CIA direct-costing time series estimates of Soviet NSE may be outlined as follows:

- Inasmuch as it is anticipated that the D_{it} estimates will be expressed in 1970 constant ruble prices, then the implicit price index derived in Column 4 of Table A-5 in Appendix A for the period 1960-1975 may be multiplied by the constant ruble, direct-costing estimates to obtain the CIA D_{it} estimates in current rubles.

- Next, the general disaggregation rules in Table 3.5 may be used by the CIA analyst to obtain the estimated sectoral composition of Soviet defense spending, $d_t^i D_{it}$, in current rubles.

- Finally, the sectoral price indices in Table 3.24 are used to convert the current ruble estimates, $d_t^i D_{it}$, into 1966 constant ruble prices. The set of wholesale sectoral price indices with turnover tax excluded, as shown in Table 3.24 a, is used whenever the burden ratio computations are made with the Leontief inverse

Table 3.24a

Wholesale Sectoral Price Indices With Turnover Tax Excluded (1966-1971) [270]

1	2	3	4	5	6	7	8
Row	Economic Sector \ Year	1966 (Base Year)	1967	1968	1969	1970	1971
1	Agriculture	1.00	1.00	1.00	1.00	1.00	1.00
2	Fuels	1.00	1.42	1.42	1.41	1.41	1.38
3	Metals	1.00	1.50	1.50	1.50	1.50	1.48
4&5	MBMW	1.00	1.00	1.00	0.98	0.98	0.90
6	Construction Materials	1.00	1.19	1.19	1.19	1.19	1.19
7	Chemicals	1.00	1.00	1.00	1.00	1.00	1.02
8	Food	1.00	0.99	0.99	0.99	1.00	1.00
9	Light Industry	1.00	1.00	1.00	1.01	1.03	1.03
10	Construction	1.00	1.00	1.00	1.00	1.00	1.00
11	Transportation and Communication	1.00	1.00	1.00	1.00	1.00	1.00
12	Trade and Distribution	1.00	1.00	0.99	0.99	0.99	0.99

Table 3.24b

Wholesale Sectoral Price Indices With Turnover Tax Included (1966-1971) [270]

1	2	3	4	5	6	7	8
Row	Economic Sector \ Year	1966 (Base Year)	1967	1968	1969	1970	1971
1	Agriculture	1.00	1.00	1.00	1.00	1.00	1.01
2	Fuels	1.00	1.07	1.07	1.13	1.37	1.37
3	Metals	1.00	1.46	1.46	1.46	1.46	1.45
4&5	MBMW	1.00	1.00	1.00	0.98	0.96	0.91
6	Construction Materials	1.00	1.19	1.19	1.19	1.19	1.19
7	Chemicals	1.00	1.00	1.00	1.00	1.00	0.99
8	Food	1.00	0.98	0.98	0.98	1.00	1.00
9	Light Industry	1.00	1.00	1.00	1.01	1.01	1.01
10	Construction	1.00	1.00	1.00	1.00	1.00	1.00
11	Transportation and Communication	1.00	1.00	1.00	1.00	1.00	1.00
12	Trade and Communication	1.00	1.00	0.99	0.99	0.99	0.99

[270] Sources of the data presented in Tables 3.24a and b are as follows:

- The industrial wholesale price indices excluding the turnover tax and including the turnover tax, respectively, for sectors 2, 3, 4&5, 6, 7, 8, and 9 were obtained from M. Bornstein's article on "Soviet Price Policy in the 1970's," Soviet Economy in a New Perspective, JEC report, October 14, 1976, Tables 1 and 2 on page 23.
- The remaining sectors were converted by means of the official wholesale price indexes in Narodnoe khoziaystvo USSR (N.Kh.), 1966 and 1974, on pages 225 and 211, respectively.

in producer's prices (i.e., Table B-1 in Appendix B). Alternatively, the set of wholesale sectoral price indices with turnover tax included, as shown in Table 3.24b, is used whenever the burden ratio computations are made with the Leontief inverse in purchaser's prices (i.e., Table B-34 in Appendix B).

The computational methodology in Appendix B may then be applied and the resulting fundamental burden incidence patterns compared with the results presented in this summary report.[269]

3.7 AN EX ANTE RESOURCE ALLOCATION ANALYSIS OF THE PROJECTED LEVEL, COMPOSITION, AND RATE OF GROWTH OF SOVIET NSE

In the two preceding sections of this report, various resource allocation experiments have been described with respect to the estimated level and sectoral composition of Soviet defense spending associated with alternative baseline estimating techniques. The summary of alternative numerical estimates of Soviet NSE in Table 2.2 covers the historical time period 1960-1975 and reflects an ex post resource allocation analysis using the methodology developed in Appendix A. Two alternative baseline estimating techniques involving the estimated sectoral composition of Soviet NSE are evaluated utilizing the methodology developed in Appendix B--which also constitutes an ex post resource allocation analysis that should be extended to include all of the alternative baseline estimating techniques identified in Table 2.2 and the entire historical time period 1960-1975. In view of the Soviet propensity to conceal the actual level, composition, and rate of growth of NSE, the currently identified baseline estimating techniques must be evaluated by means of an ex ante resource allocation analysis. In recent testimony before the Congressional Subcommittee on Priorities and Economy in Government, the senior specialist in Soviet Economics from the Congressional Research Service of the Library of Congress, John P. Hardt, made the following recommendations:

> I would suggest we can improve on what we are doing. Whether or not we can reach the point at which we can be satisfied of feeling the system is adequate in large part is up to the disclosure policy of the Soviets.

[269] Stanley Cohn's estimates of $d_t^i D_{it}$ in Tables B-8a and B-8b are expressed in current rubles and therefore had to be divided by the sectoral price indices in Table 3.24.

order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).

- Column 8 is taken from Column 5; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Column 9 is taken from Column 6; a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

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> But, specifically, we have used methods of economic estimating (Soviet defense spending) based on their order of battle, we have used methods of looking at the economy and trying to impute measures on the basis of allocating resources known to be in a civilian area and then estimating what the known areas were and building up an economic budget.
>
> What I am specifically suggesting is more additional measures which will improve our insights, and I have in mind using the kind of Soviet economic models that have developed in the recent Joint Economic Committee publication, and I am particularly referring to the model (SOVMOD III) developed at the University of Pennsylvania's Wharton School, Stanford Research Institute, the Foreign Demographic Analysis Division of the Department of Commerce, and Duke University, to look at the time sequence of the 5-year plan, the 15- year plan, and make, as they do, assessments of the military implications of changes using different scenarios.
>
> That would be incremental to our understanding and my comments are not intended to suggest the absence of utility in the present method, but to indicate potential areas of improvement. Net assessment analysis has been a recent improvement, I think, in our military intelligence area. I think we can likewise improve in the economic area.
>
> This is not to suggest we discard methodology but that we change and improve our approach.[271]

An ex ante resource allocation analysis is associated with the projected level, composition, and rate of growth of Soviet defense spending beyond the historical time period.[272] The Director of the CIA, Admiral Stansfield Turner, describes the projected values of Soviet NSE associated with the CIA direct costing methodology as follows:

> I should point out that these estimates are calculated in terms of 1970 ruble prices. This use of a constant price base has a dual purpose.
>
> First, the resulting trend in defense spending reflects only real changes in the level of Soviet military activities rather than purely monetary change resulting from price inflation.
>
> Second, all CIA estimates of Soviet economic performance are calculated on the same basis--that is in constant 1970 prices. This use of the same base year for prices allows us to combine the economic and military-economic data to analyze the economic impact of defense.

[271] Allocation of Resources in the Soviet Union and China--1977, Hearings before the Subcommittee on Priorities and Economy in Government of the Joint Economic Committee, Congress of the United States, Part 3, June 23 and 30 (Executive Sessions), and July 6, 1977, page 184.

[272] The distinction between forecasts and projections adopted by the Joint Economic Committee and observed in this report is defined on page C-1 of Appendix C.

> Although no single measure adequately describes the economic impact of the Soviet defense effort, defense spending as a share of gross national product is often used for this purpose.
>
> When measured according to a definition of defense activities roughly comparable to that used in the U.S., the Soviet defense effort absorbs some 11-12 percent of Soviet GNP. When based on the broader definition of defense, the share is about 12-13 percent. Because the rate of growth in defense spending and in GNP were roughly the same during 1970-1976, there was little change over the period in the share taken by defense.
>
> The percentage of machinery output alloted to defense is another economic aggregate used to describe the impact of defense programs on the economy as a whole. At present, Soviet defense takes about one-third of the output of the machine-building and metal-working sector--the sector that produces investment goods as well as military weapons and equipment.
>
> The defense bite is also large in metallurgy (about one-fifth), chemicals (about one-sixth), and energy (about one-sixth).
>
> Even these measurements tend to understate the impact on the Soviet economy because they fail to take qualitative considerations into account.
>
> Defense takes a proportionally larger share of the economy's high-grade scientific, technical, and managerial talent and draws heavily on the output of scarce and high-quality materials, components and equipment. Integrated circuits, for example, are almost totally consumed by the military.
>
> As I mentioned earlier, we expect the long term upward momentum of Soviet defense spending to continue into the 1980's at an annual growth rate of about 4 to 5 percent. 273

The numerical estimates of Soviet NSE in Table 2.2 utilizing the CIA direct-costing methodology have been converted to a current ruble basis by applying a two percent inflation rate. However, the Director of the Defense Intelligence Agency (DIA), Lt. General Samuel V. Wilson, expresses his point of view with regard to the current ruble estimates as follows:

> A separate estimate, costed in rubles, is developed in an attempt to gain an appreciation for defense outlays as seen by Soviet leaders. In the last 2 years, considerable DIA and CIA effort has gone into the analysis of all of the known evidence and methodologies. While we do not have, and may never have, definitive answers as to all the ramifications of Soviet defense outlays, we can say that Soviet defense is more of an economic burden, given higher priority, and a greater commitment than we previously believed...

[273] Allocations of Resources in the Soviet Union and China--1977, Op. Cit., pages 37-38; underlining has been added for emphasis.

order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).

- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

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> While we agree with the (intelligence) community estimate for 1970 to 1976 when valued in constant 1970 ruble prices, we believe that an estimate of Soviet defense spending published in the People's Republic of China weekly Peking Review, a magazine, may accurately represent the growth rate and total expressed in current prices. The Peking Review series is supported by information from classified sources. These data indicate a 1975 Soviet defense total of over 70 billion rubles and an economic burden of between 14 and 15 percent.
>
> Using these current ruble values and Soviet economic plans for 1976 to 1980, we are able to project that Soviet defense outlays will continue to rise at about the same rate (i.e., 8 to 11 percent) as the previous 5 years.[274] We realize, of course, that relying on Soviet plan data and on Soviet or Communist statements is not generally advisable. These figures are not well defined and may include inflated prices. Nonetheless, we believe that these figures approximate the values as seen by the Soviet policymakers and may realistically reflect the growing costs of new technologies.
>
> Soviet production technology has become increasingly sophisticated and the Soviet Union is steadily gaining the ability to produce complex systems. With this ability comes the inevitable cost increases associated with modern technology.[275]

The Chinese estimates of Soviet defense spending presented in Table 2.2 are the same current ruble estimates cited by General Wilson. Consequently, the difference between the CIA and the Chinese current ruble estimates in Table 2.2 may be largely attributed to alternative inflation rates used to convert the constant 1970 ruble estimates of Soviet NSE cited by Admiral Turner. This impression is reinforced by the following additional remark by General Wilson:

> I don't feel that we (DIA) are very far apart from the CIA. We are talking of 11 to 13 percent (defense share of Soviet GNP), as opposed to 14 to 15 percent. As I indicated to you last year, while earlier there had been some contentiousness between ourselves

[274] This estimate of an 8-10 percent annual growth rate is based upon the 1975 estimate of 70 billion rubles for Soviet NSE in 1975 and a 1970 estimate of 40-45 billion rubles (using a narrow definition of defense which encompasses a range of activities comparable to those of the US), as well as a 1970 estimate of 45-50 billion rubles (using a broader definition of defense which the Soviets may use and which encompasses such additional military-operated programs as the space program). Using the formula $70=(1+r)^5(42.5)$, then r is 11 percent, while using $70=(1+r)^5(47.5)$, then r is 8 percent. Presumably, this is the rate of growth used to project the Chinese estimates in current rubles for the period 1976-1980.

[275] Allocations of Resources in the Soviet Union and China--1977, Op. Cit., pages 76-78; underlining has been added for emphasis.

> and the CIA, that has all but disappeared....So, we have worked with the same data, the same information. We have reacted to it, I think, a little more vigorously than they have....The big thing that I wanted to get across to you is that we do work very, very closely with CIA. We share the same data and make contributions to the same common goal, and we come out at the end somewhat differently, but nowhere near as divergent as we were some several years ago. [276]

3.7.1 Alternative Projection Methodologies

A more detailed methodology for projecting Soviet NSE for the period of the 10th Five-Year Plan (FYP), 1976-1980, has recently been developed by Bill Lee, who explains it as follows:

> Planned growth in (Soviet) defense expenditures can be estimated from income data. Planned growth in outlays for procurement of weapons can be estimated from a combination of industrial output and investment data. Each method provides only an approximation of the planned growth (or decline) in defense expenditures and each suffers from data gaps. Nevertheless, the two methods are independent of each other and so provide a mutual check.
>
> - The first method, using national income data, recognizes that national income (and GNP), by definition, consists of three end-use components: consumption, investment, and defense. If one knows the total (i.e., national income or GNP) and two of the components (e.g., consumption and investment) the third component falls out. Similarly, if one knows the planned growth for the total and for two of the components, and the weight (percentage share) of each component in the base period, then the planned growth of the third component (e.g., can be derived)....Thus, the data required to solve for the approximate planned growth in defense expenditures in each FYP are:
>
>   - Weight of investment (in GNP) in the base period and planned growth in the FYP,
>   - Weight of consumption (in GNP) in the base period and planned growth in the FYP,
>   - Weight of defense (in GNP) in the base period, and
>   - Planned growth of national income in the FYP.
>
>   The implicit rate of growth planned for defense spending is the unknown to be solved, recognizing that only an approximation is possible given the range of uncertainty in the data.

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[276] Ibid., pages 101-102.

in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).

• Entries in this table without parentheses reflect the 54% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

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- The second method derives the implicit planned growth of defense spending in each FYP from the planned growth in outlays for the procurement of weapons and certain assumptions about the planned growth in:

  - Pay, operations maintenance, and construction (POMC); and

  - RDT&E and space.

  Only the procurement target can be derived from the FYP data. For POMC, rather heroic assumptions are required. But growth in planned outlays for military RDT&E and space can be estimated or extrapolated by assumptions that seem well founded in research and experience. [277]

The actual implementation of Bill Lee's projection methodology is illustrated in Figure 3.0 where Bill Lee's projected estimates for the period 1976-1980 are identified by means of the green line (i.e., 74, 83, 89, 90, and 110 billion rubles, respectively).[278] These estimates represent the composite values derived by means of his two projection techniques using Soviet plan data for the 10th FYP on an establishment basis. Bill Lee's projected estimates of Soviet NSE would appear to be very close to those of the Chinese using an average annual growth rate of 10% over the projection period 1976-1980 (i.e., 77.7, 85.5, 94.0, 103.4, and 113.7 billion rubles, respectively). For purposes of comparison, the CIA's projected values of Soviet NSE in current rubles for the period 1976-1980 are identified in Figure 3.0 by means of the black line which reflects an average annual growth rate of 6.5 percent (i.e., 62, 66, 70, 75, and 80 billion rubles, respectively). These figures represent a two percent inflation rate and a 4.5 real growth rate based upon a recent CIA report.[279]

These alternative projections may be placed in a better perspective by comparing all of the current baseline estimates of Soviet NSE in Figure 3.1 for the historical period 1960-1975. As may be observed:

- The time series for the Official Soviet Defense Budget is identified by means of a blue line;
- Stanley Cohn's numerical estimates in Table 2.2 (i.e., State Reserve Basis and Final Demand Basis) are represented by red lines;

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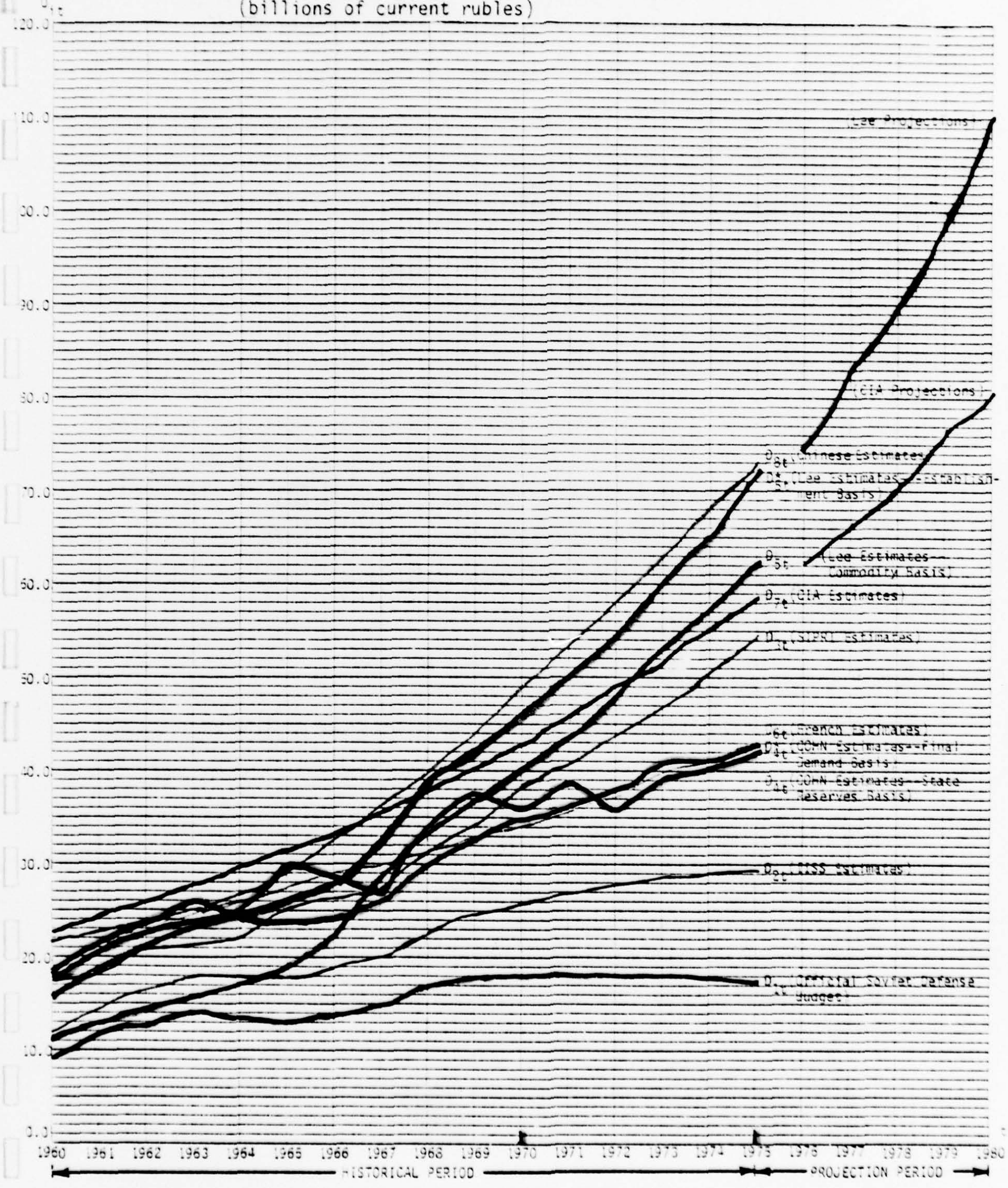
277 William T. Lee, "Soviet Defense Spending: Planned Growth 1976-1980," Strategic Review, Winter 1977, pages 75 and 76; underlining has been added for emphasis.

278 William T. Lee, "Soviet Defense Expenditures in the 10th FYP," Ostewropa, December 1977, Table 5, page 288.

279 Estimated Soviet Defense Spending: Trends and Prospects, CIA report SR 78-10121, June 1978.

- Column 9 is taken from Column 6: a "non-decreasing" burden ratio trend is required for all estimation techniques in order to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).
- Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

Figure 3.1 Current Baseline Estimates of Soviet Defense Expenditures for the Historical Period 1960-1975 and the Projection Period 1976-1980 (billions of current rubles)



... to qualify a particular sector for inclusion in the fundamental burden incidence pattern (as modified).

• Entries in this table without parentheses reflect the 64% & 36% hypothesis with respect to expenditures of military pay in the Food and Light Industry sectors, respectively. On the other hand, entries with parentheses reflect the alternative 50% & 50% hypothesis.

- Bill Lee's alternative numerical estimates (i.e., Establishment Basis and Commodity Basis) are represented by green lines;
- The CIA direct-costing estimates are represented by a solid black line; and
- All of the remaining numerical estimates are represented by gray lines.

As may be observed, the historical period 1960-1975 is partitioned into two epoch periods which are identified by means of the red tick marks at the bottom of Figure 3.1; i.e., 1960-1969 and 1970-1975. There is much less dispersion among the numerical time series estimates within the first epoch period than within the second epoch period. The greater dispersion among the numerical estimates within the second epoch period may easily be observed inasmuch as the range between the high and the low values of the estimates in 1975 is almost twice the range for 1970. In this context, it should be noted that the CIA's projected values for the period 1976-1980 represent an upper boundary of the "possible" projected values for the following baseline estimating techniques:

- The Official Soviet Defense Budget,
- IISS estimates,
- SIPRI estimates,
- Stanley Cohn's estimates,
- French estimates, and
- CIA estimates.

By contrast, the much higher values projected by Bill Lee for the period 1976-1980 may be associated with the "possible" projected values for the following baseline estimating techniques:

- Bill Lee's estimates, and the
- Chinese estimates--which have been officially supported by the DIA.

It should also be noted that the same type of clustering with respect to the alternative baseline methodology estimates in Table 2.2 was established in Appendix C based upon the "low" and "high" average values of the rate of growth parameter.

A more sophisticated methodology for projecting Soviet defense expenditures and other elements associated with Soviet resource allocation requires an econo-

metric model of the Soviet economy, such as was suggested by Professor John P. Hardt.[280] In this context, the following three well-known econometric models of the Soviet economy are reviewed in some detail in Appendix C:

- The Bergendorff-Strangert Model,
- The Niwa Models, and
- The SRI-WEFA Models.

The importance of using a model for the evaluation of Soviet ex ante resource allocation is explained by Professor Malinvaud as follows:

> A model is the formal representation of the notions that we have about a phenomenon. These notions, often called the "theory of the phenomenon," are expressed by a set of assumptions about the essential elements of the phenomenon and the laws which regulate it. They are generally expressed in terms of a mathematical system, and this system is then called "the model".
>
> By basing our reasoning on the model, we can investigate the logical consequences of the assumptions we have made, compare them with observations and thus find ourselves better equipped to understand the real world and to act efficiently on it.[281]

3.7.2 The Bergendorff-Strangert Model

Of the foregoing models, the Bergendorff-Strangert model is the most aggregative and, as indicated in Figure C-3 of Appendix C, the three experimental conditions or resource allocation rules associated with this model may be summarized as follows:

- Investment is exogenous and consumption is endogenously determined as a residual (i.e., consumption vs. defense spending);
- Consumption is exogenous and investment is endogenously determined as a residual (i.e., GNP vs. defense spending); and

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280 The general limitation with respect to the use of Soviet Five-Year Plan data, upon which to project Soviet NSE, is that alternative scenarios reflecting different assumptions cannot be readily incorporated. In addition, longer run projections (i.e., beyond five years) are not possible. An econometric model overcomes these limitations and permits experiments to be conducted.

281 E. Malinvaud, Statistical Methods of Econometrics, Rand McNally, Chicago, 1966, page 49.

- Both consumption and investment are endogenously determined with their shares of non-defense gross national product provided exogenously (i.e., consumption and investment vs. defense spending).[282]

These three alternative allocation rules define the three basic experimental designs for evaluating the impact of resource allocation associated with a given rate of growth in Soviet defense spending. Within each experimental design or set of allocation rules, the following "sensitivity analysis" experiments with respect to resource allocation may be performed:

- The production function for the industrial sector is changed from Cobb-Douglas (with $\sigma = 1$) to CES (with $\sigma = 0.5$) in order to examine the consequences of an elasticity of substitution between capital and labor less than unity when the given rate of growth in Soviet defense expenditures changes;
- The technological progress parameter of the industrial sector is changed in order to examine the consequences of improved managerial performance or the importation of foreign technology when the given rate of growth in Soviet defense expenditures changes;
- The defense share of Soviet GNP (i.e., the burden ratio) is changed in order to examine the consequences of reducing the percentage of non-defense GNP available for consumption and investment when the given rate of growth in Soviet defense expenditures changes; and
- The sectoral composition or "mix" of Soviet defense final demand between the industrial and construction sectors is changed in order to examine the impact upon resource allocation when the given rate of growth in Soviet defense expenditure changes.[283]

The combination of the three alternative sets of allocation rules and the four alternative sensitivity analyses constitutes twelve "ex ante" resource allocation experiments for projecting Soviet defense spending. In the Bergendorff-Strangert model, the projection period is 1976-1985, and the rate of growth of Soviet NSE (i.e., $\dot{D}/D$) is used to obtain an ex ante resource allocation analysis.

A detailed examination of each of the foregoing experiments is provided in Appendix C.[284] It should be noted that there is a basic distinction between a "primary" and a "secondary" "ex ante" resource allocation effect associated with projected Soviet defense expenditures. These effects are defined as follows:

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[282] Appendix C, pages C-5, C-17, and C-18.

[283] Appendix C, page 20 and Figures C-3, C-4, and C-5 on pages C-21, C-22, and C-23.

[284] Appendix C, pages C-24 to C-37.

- A primary "ex ante" resource allocation effect is associated with the change in projected Soviet defense expenditures when all other factors are held constant; and
- A secondary "ex ante" resource allocation effect is associated with a change in some other experimental factor with no change in the projected Soviet defense expenditures.

In order to illustrate the importance which the Soviets attach to the development of their fuel and other energy resources, an "energy constraint" is introduced into the Bergendorff-Strangert model.[285] If this energy constraint were satisfied, then the Soviet Union could sustain this economic growth rate utilizing only domestic energy sources. However, if this energy constraint were violated, then the Soviet Union could sustain this economic growth rate only by depleting its domestic energy reserves or, more likely, by importing energy supplies from foreign sources. Therefore, the Soviet policy of maintaining its "energy self-sufficiency" can be attained only if the energy constraint were satisfied in each "ex ante" resource allocation experiment for projecting Soviet defense spending.

The interaction of Soviet defense and energy policies from the standpoint of maintaining economic growth was particularly stressed by John P. Hardt in his recent testimony before the Congressional Subcommittee on Priorities and Economy in Government as follows:

> As suggested in the paper attached to my testimony, prepared for presentation to NATO and the North Atlantic Assembly in May, the Soviet leadership faces a dilemma in their choices between military buildup and modernization. They appear to be committed to a program designed to bring about the kind of miracle in economic change that American technology brought to the Western industrial nations in the postwar period. Committed as they are to a series of multi-billion ruble programs in energy, metals, regional development (e.g., the Baikal-Amur Railroad), computer-related management, agriculture, modernization, and automotive transport, they have fallen short in the full commitment to timely completion of the projects. Because each of the giant projects requires foreign technology, credits and balance of payments problems have limited actual imports. As each

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285 Appendix C, pages C-28 to C-32.

> of the projects requires substantially more domestic investment and human resources, the conflict of defense priorities seems implicit.
>
> A case study of this general Soviet problem of modernization involving Western imports and investment priorities is their energy policy. Under the best of circumstances, energy will be a problem area for the U.S.S.R. as it is for us. There is no doubt that Soviet petroleum reserve and output will not be adequate to meet future extrapolation of past trends in demand. However, with substantially increased investment and stepped up energy equipment imports from the West, and especially from the United States, the Soviet's energy crisis might be ameliorated. A crucial question to U.S. policy makers might be whether exports of energy technology to the U.S.S.R. would reinforce pressures to shift resources from the military to energy programs. Whatever the answer to this significant question, the type of analysis and information used would be different from that normally presented to this Committee. It might be a useful case study in providing a new approach to Soviet defense allocation estimates. [286]

The change in the elasticity of substitution between capital and labor resources influences the rate of economic growth in the Soviet economy. A more realistic projection of Soviet NSE and its associated effects upon resource allocation requires the use of the appropriate production function to represent each economic sector. In addition, the importance of importing foreign technology must be properly reflected in the projections and ex ante resource allocation analysis. This is again highlighted by John P. Hardt as follows:

> In any case, the advantages of economic interdependence have been well illustrated by the "economic miracles" of the advanced, Western industrial nations. The Soviet leaders were encouraged by the prospects held out by the agreements with the United States following the 1972 Summit that forecast improved trade facilities and the availability of long-term, low-interest government credits. The formula discussed for the West Siberian natural gas project, "North Star," was especially attractive in that the multi-billion ruble project was to be supplied with plant and equipment from the United States on a priority basis for development of the pipeline, liquefaction and energy transport facilities with no repayment required until after the facilities were operative. The sequential payback arrangement was then to be at reasonably favorable terms from the output of future gas generated in the new facilities, developed largely with Western technology and facilitated by Western credit. Although this project involved the reallocation of domestic Soviet investment resources within the Soviet plan, it posed no significant problem in terms of diversion of hard currency from other projects

[286] Allocation of Resources in the Soviet Union and China--1977, Op. Cit., page 169; underlining has been added for emphasis.

> or incurring onerous indebtedness that might influence short-term import policies....
>
> However, as preparation for the Tenth Five-Year Plan (1976-1980) proceeded, leadership interest in technological transfer, various forms of economic interdependence, and a broadening of sectors of priority for modernization involving Western technology continued. This interest was dampened by hard currency trade deficits and rising indebtedness. Emphasis was given, and is still being given, to various modes of financing, and these financing ventures have the common feature of giving priority to those that provide returns or repayment out of products developed from imported technology in specific projects. So-called compensation agreements, i.e., projects financed by purchase of products from completed enterprises, became the vogue. This new formula also includes industrial cooperation characterized by royalties, quality control and other aspects of Western managerial involvement; it is expected by 1980 to account for as much as 40 percent of U.S.-U.S.S.R. commercial relations. The prototype is being set by the Bendix spark plug agreement now in final stages of negotiation. The common features of these institutional arrangements are that they improve the prospects of effective technology transfer and ease the hard currency deficit problem....
>
> Western analyses on the impact to date of imported technology suggest that the Soviet leadership has correctly assumed that Western technology should be a major factor in accelerating economic performance. Economy-wide, as well as individual industry studies, although preliminary, suggest a multiplier effect of three to four in value terms comparing the value of imports of Western plant and equipment with increased output from Soviet industry during the previous five-year plan periods.[287]

The importance of "compensation agreements" to finance the Soviet imports of Western machinery and equipment must be incorporated into the econometric models used to evaluate the ex ante resource allocation impacts associated with projections of Soviet defense spending. The Bergendorff-Strangert model and the Niwa model are too aggregative for this degree of sensitivity, so the much more disaggregated, sophisticated SRI-WEFA model (SOVMOD III) must be used.

3.7.3 The SRI-WEFA Model

The SRI-WEFA model of the Soviet economy will also provide the analytical framework for an ex ante resource allocation analysis of the projected level and

[287] Ibid, pages 172-174; underlining has been added for emphasis.

composition of Soviet NSE, as well as of the rate of growth. The general structure of SOVMOD III is reviewed in Appendix C,[288] along with the historical development of the defense expenditure element within the model itself.[289] This element provides the framework for evaluating the following hypothesis which was enunciated by Bill Lee at the workshop on economic conflict sponsored by the Office of Naval Research:

> On the subject of opportunity costs, the hypothesis I would like to offer goes something like this: the opportunity cost of defense expenditures in the Soviet Union is very high because, first of all, there's a fairly direct trade off between defense and investment. There's not much of a trade off between defense and consumption, at least not directly and in the short run. In the longer run, there is a trade off, but in the short run, it's very much defense versus investment.[290]

The evaluation is based upon the use of Cobb-Douglas production functions to drive SOVMOD III. In this context, it is apparent that Bill Lee's "short-run trade-off" hypothesis is not supported by the results of the SRI report to the Arms Control and Disarmament Agency (ACDA) when his own procurement estimates are evaluated. Ironically, however, Bill Lee's "short-run trade-off" hypothesis is supported by the estimated "simulation multipliers" only when Stanley Cohn's procurement estimates are evaluated, and these are much lower in rate, trend, and magnitude than Bill Lee's estimates. As a result, Donald Green and Daniel Bond of SRI have expressed dissatisfaction with the results of their evaluation and comparison exercise as described in Appendix C.[291] Therefore, since SOVMOD III is essentially a supply-determined, long-run growth model driven by demography and its production functions, then the Cobb-Douglas specification should be changed to a more general form--which is accomplished on the basis of the detailed review of the SRI-WEFA engineering approach to Soviet production in Appendix C.[292]

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[288] Appendix C, pages C-40 to C-47.

[289] Appendix C, pages C-48 to C-53.

[290] Appendix D, page D-9.

[291] Appendix C, page C-53.

[292] Appendix C, pages C-53 to C-57.

In this review, it is rigorously demonstrated that Donald Green's ex ante production function can be related to a Variable Elasticity of Substitution (VES) production function recently developed by Professor Karl W. Roskamp of Wayne State University.[293] The VES production function contains the Constant Elasticity of Substitution (CES) and the Cobb-Douglas production functions as special cases.[294] This correspondence may be associated with a parameter (i.e., γ) to reflect the exercise of "political power" in wage determination, and with a parameter (i.e., τ) to reflect the influence of "institutional rigidities" in the adjustment of the capital-labor ratio to changes in the prevailing wage rate.[295] It is also necessary to disaggregate the Soviet capital stock between domestic capital and imported machinery and equipment from the West.[296]

This disaggregation provides the basis for evaluating the importance of technology transfer from the West in terms of the possible "leverage" involved as recently suggested by Senator William Proxmire from Wisconsin:

> You say it remains to be seen whether (Soviet) economic problems increase their incentives to reduce military spending. Assume the adverse trends result in economic stagnation or worse. What leverage does the United States gain with regard to our sophisticated equipment and technology which the Soviets need as well as our grain, which they may need again?...Let me put it a little different way.

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293 K.W. Roskamp, "A Generalized Production Function for West German Industries," Weltwirtschaftkiches Archiv, Band 112, Heft 4, 1976, pages 749-753, for the general VES family of first-degree, homogenous production functions. An empirical implementation is provided by K.W. Roskamp in "Labor Productivity and the Elasticity of Factor Substitution in West German Industries 1950-1960," The Review of Economics and Statistics, Volume 59, Number 3, August 1977, pages 366-371. The ex ante production function was developed by D.W. Green in "The Microfoundations of Soviet Production Functions: An Engineering Approach," SRI-WEFA Working Paper #45, April 1976.

294 Appendix C, pages C-57 to C-69.

295 This relationship between Karl Roskamp's parameters, γ and τ, and Donald Green's parameters, ℓ_t and q_t, is defined in Equation (C-36) on page C-63 of Appendix C.

296 Appendix C, pages C-70 to C-74.

- One view is we might induce the Soviets to cut spending by withholding our technology and other trade, thereby forcing them to reallocate military resources to more productive uses. That is one view.
- Another view is that they are more likely to invest heavily in civilian projects if they are assured of needed Western technology. We could make it clear that they would have it with the notion they would be likely to invest more capital in that technology and in the industrial development and, therefore, less in military.[297]

The first point of view expressed by Senator Proxmire may be interpreted as a "military necessity" hypothesis with regard to the Soviet importation of Western technology. The second point of view, on the other hand, may be interpreted as the usual "economic necessity" hypothesis with regard to the Soviet import of Western machinery and equipment. Another subject of particular importance is Soviet energy policy as previously highlighted by John P. Hardt. However, there is some disagreement between the CIA and the DIA on the projected decline in Soviet oil production during the 1980s. Admiral Turner, Director of the CIA, presents the Agency's point of view:

> All growth in oil output through 1980 is planned to come from West Siberia, where the inhospitable climate and difficult terrain complicate operations. In 1976, about one-fifth of national production came from the giant Samotlor field alone, but production at Samotlor will peak in the next year or so and will hold at peak levels no more than four years. Because of extensive water flooding, the field is already experiencing rapid water incursion. As a result, increasing quantities of fluid must be lifted to recover a given quantity of oil.
>
> The downturn in oil production probably will be sharp. Although the discovery of new fields may arrest or slow the decline, such respites are likely to be temporary. Depletion of existing fields is now very rapid and exploration and development of frontier areas is a slow and costly process. To stave off or slow the expected fall in production even temporarily, the Soviets will need capacity submersible pumps made only in the United States. Without them, oil production will fall sooner rather than later.
>
> Beyond the mid-1980's, the U.S.S.R. is counting on large new supplies of oil and development of alternative energy sources--coal, natural gas and hydro-electric power. Even if new major sources are developed, most of these lie east of the Urals, far

[297] Allocation of Resources in the Soviet Union and China--1977, Op. Cit., page 128; underlining has been added for emphasis.

from major industrial and population centers. Moreover, their development will take years, require massive capital investment, and incur continuing high transportation costs.

> Because of the projected fall in oil production and even if the development of other energy sources--especially gas and coal--is pushed to the maximum, we expect a sharp slowdown in the rate of growth of total energy output.[298]

The alternative point of view has been expressed by Mr. Norbert D. Michaud, an Operations Research Analyst in the Military Economics Group of DIA, as follows:

> There is quite a bit of concern in regard to (Soviet) energy production, particularly their oil production in the 1980's. As you heard from the CIA last week, they contend that their rate of oil production will probably decline in the 1980s as the CIA prognostication at this time shows. We are not in full agreement with that. Other people seem to think that it will continue and not necessarily be a part of the problem.
>
> I think I perhaps should refer to (General Wilson) on this. I think that that is DIA's position at this time, that we do not believe that the rate of flow will necessarily decline in the 1980s.
>
> There is very little information on this whole oil question at this time. There is a great deal of research going into these estimates as to the reservoirs that the Soviets are now exploiting. I think it will be some time before we can get a better fix on the whole situation.[299]

This debate with regard to a potential Soviet energy crisis during the 1980s has been placed in perspective by John P. Hardt as follows:

> Senator Proxmire, we have been talking a great deal about Soviet energy of late and it is generally agreed that the Soviet oil production in particular is going to fall short of their desired levels (DIA view) and perhaps their needs (CIA view). Their natural gas deposits and reserves are quite substantial, but the ability to get them to their users, domestic and foreign, is going to be difficult and this is likewise true with coal.
>
> In each of those cases we can identify specific areas in which Western technology, particularly U.S. technology would represent a critical factor in improving their ability to meet

[298] Ibid., page 34; underlining has been added for emphasis.

[299] Ibid, page 108; underlining has been added for emphasis.

their required goals. In each of those cases, whether they be production facilities for oil, such as submersible pumps or offshore drilling rigs, or for pipe for natural gas or other specific areas, we could identify to be precise about our Western technology sales. They would require, in addition to importing these elements of Western technology, investments on their own part in order to make them productive in terms of output and use of energy, and in that case <u>I would support the notion that the pressures on domestic investment would be increased by increased imports of Western technology</u>....

It is a very difficult process for us to use explicit leverage. I would certainly agree with Mr. Becker's notion, as I understand it, that we get as much as we can politically, if that is the sense of the comment, out of these arrangements, that we use them for maximum influence elsewhere.[300]

3.7.4 An Application of SOVMOD III

The application of SOVMOD III for purposes of examining and evaluating the importance of increased imports of Western technology embodied in machinery and equipment, as well as non-machinery items such as large-diameter pipe and silicon chips, is described by Professor Philip Hanson, Senior Lecturer in the Center for Russian and East European Studies at the University of Birmingham (Birmingham, England), as follows:

A series of exercises conducted by Donald W. Green and Herbert S. Levine with the SOVMOD macro-econometric model of the Soviet economy developed at the University of Pennsylvania have yielded aggregate figures for the Soviet Industrial sector which are also remarkably high. They indicate that the net addition to output resulting from a unit increase in the stock of imported Western machinery in Soviet industry is 8-14 times the corresponding effect of a unit increase in the "indigenous" capital stock. Since the stock of Western machinery is a small part of the total, this does not imply that Soviet industrial growth in recent years has been dominated by the contribution of Western technology, but it does imply that that contribution has been significant. Thus, in one exercise, it was calculated that variations of 10 percent either way in the projected total of Western machinery imports for 1973-80 would generate slight but perceptible changes in Soviet total industrial output in 1980, from an index of 126.6 (1975 equals 100)

[300] Ibid., pages 181-182; parenthetical information and underlining have been added for clarity and emphasis, respectively.

to 126.2 in the case of a reduction in such imports, and to 127.0 in the case of an increase. 301 Slight though these projected changes are, it must be remembered that they arise (in the model) from relatively small variations in a relatively small flow of imports. 302

However, these preliminary results are very dependent upon a number of crucial assumptions which are explained by Philip Hanson as follows:

> At the same time, Green and Levine stress that these are experimental calculations, and that their interpretation is in any case a complex matter. Indeed, a number of questions can be raised about these calculations.
>
> - the valuation of the imports,
> - the time lags before the imports enter the capital stock, and
> - the specification of the production functions from which their contribution to output is estimated.
>
> There is also a fundamental difficulty in identifying the contribution of such imports net of (for example) the effects of preferential allocations to import-intensive projects of cooperating domestic inputs. These cooperating domestic inputs include such intangibles as the time and attention of central officials (which may have a high opportunity cost to the rest of the economy).
>
> A recent, and as yet unpublished, paper by Martin L. Weitzman of the Massachusetts Institute of Technology[303] raises further questions by showing that the use of the stock of imported Western machinery as a separate explanatory variable in production function analysis of recent Soviet industrial growth does not improve statistically the explanation of such growth.
>
> In other words, despite the Green-Levine findings, one cannot definitively reject the hypothesis that the impact on output, at the margin, of this imported machinery does not in fact differ from that of "indigenous" machinery. 304

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[301] D.W. Green and H.S. Levine, "Soviet Machinery Imports," Survey (London), Volume 23, Number 2, Spring 1977-78, pages 112-126.

[302] Philip Hanson, "Western Technology in the Soviet Economy, Problems of Communism, November-December 1978, page 28; parenthetical information and underlining have been added for clarity and emphasis, respectively.

[303] M.L. Weitzman, "Technology Transfer to the USSR: An Econometric Analysis," an unpublished paper originating from MIT, Cambridge, Massachusetts, August 1978.

[304] Philip Hanson, "Western Technology in the Soviet Economy," Op. Cit., pages 28-29; underlining has been added for emphasis.

Consequently, the development of an ex ante VES production function, which contains the CES and Cobb-Douglas production function specifications as special cases, in Appendix C provides the necessary generalization of one of the crucial assumptions cited by Philip Hanson. The additional theoretical and empirical research outlined in Appendix C must also be used to evaluate the recent results of production function analysis obtained by Martin L. Weitzman (as reported by Philip Hanson) which are now within the framework of an ex ante VES production function.[305] Finally, the import demand equations used by Donald Green and Herbert Levine are respecified in Appendix C to replace the "détente-trend" explanatory variable with a "compensation agreements" explanatory variable.[306] Inasmuch as the demand for machinery imports depends upon the three general factors which follow, then it is hypothesized in Appendix C that the willingness of Soviet authorities to import machinery and equipment from the West depends upon the percentage of medium and long-term Soviet indebtedness covered by compensation agreements:

- The ability to import,
- The willingness to import, and
- The influence of extraneous factors.

This is an hypothesis which appears to warrant future empirical testing.[307]

The general rationale for concentrating upon machinery and equipment imports from the West in order to evaluate the overall importance of technology transfer is summarized by Philip Hanson as follows:

- First, while other producer goods may also embody new technologies with potential for increasing their user's productivity levels, the major productivity-enhancing potential of new technologies in embodied form is generally considered to be in machinery and equipment.
- Second, although not all machinery embodies technologies new to its purchasers, anecdotal evidence and the "Methodological Guidelines" of the USSR State Planning

[305] See Appendix C, pages C-69 and C-70.

[306] See Appendix C, pages C-75 to C-87 for a review of the SOVMOD III import demand equations. Pages C-88 to C-92 of Appendix C describe development of the "compensation agreements" explanatory variable and the new specifications for the import demand equations.

[307] See Appendix C, pages C-93 to C-98. The definition of counter-trade practices involved in Soviet trade policy is defined in Footnote 95 on page C-79 of Appendix C.

Commission (Gosplan) strongly suggest that Soviet planners do not allocate hard currency to machinery imports unless the relevant machine-building ministry attests that it can not itself provide, within the time-frame established by the plan, machinery of the type and parameters required.

- Finally, other important transfer channels, such as purchase of know-how and licenses and the receipt of training, are in Soviet practice mostly connected with major plant purchases, and the values of the technology acquired are included within the reported values of these package deals.[308]

In this context, Philip Hanson has constructed a time series of Soviet machinery and equipment imports from the West in which the estimated ruble value in 1969 investment prices is treated as an indicator of the changing dimensions over time of commercial flows of technology from the West to the USSR. As he explains,

> We can use Table 1 to put technology transfer to the USSR in perspective.

Table 1

Soviet Imports of Machinery and Transport Equipment from the West, 1955-1977[309]

1	2	3	4
Year	Value in US dollars, current prices, f.o.b. (millions)	Estimated ruble value, in 1969 investment prices (millions)	Imports as share of domestic machinery investment in the following year (percent)
1955	104	148	2.0
1956	139	188	2.4
1957	128	166	1.8
1958	123	158	1.6
1959	177	227	2.2
1960	310	393	3.4
1961	390	472	3.6
1962	436	510	3.6
1963	402	467	2.8
1964	489	561	3.2
1965	366	421	2.2
1966	395	436	2.2
1967	457	499	2.4
1968	639	721	3.2
1969	889	966	3.8
1970	905	913	3.4
1971	840	796	2.8
1972	1,126	959	3.0
1973	1,574	1,091	3.2
1974	2,094	1,316	3.4
1975	4,184	2,287	5.6[310]
1976	4,259	2,282	5.5
1977	4,571	n.a.	n.a.

[308] Philip Hanson, "Western Technology in the Soviet Economy," Op. Cit., page 24; underlining has been added for emphasis.

[309] The imports identified in this table are those covered by Section 7 of Standard International Trade Classification (SITC 7). These data exclude imports from Finland--a barter-trade partner having a special political relationship with the USSR.

[310] This figure is related to 1977 planned (rather than reported) investment because the latter was not currently available.

In its commercial form, at least, technology transfer represents only a very small share of Soviet equipment investment (Column 4). This proportion has grown somewhat since the mid-1950s, but the rise has been neither strong nor continuous. The percentages for the latter half of the period probably somewhat understate the share of Western machinery in total Soviet equipment investment, since they do not allow for unacknowledged inflation present in Soviet prices for USSR-produced machinery. However, while correction for this phenomenon might raise the mid-1970s share to 6 percent or so, it would not alter the general picture.

As can be seen, fluctuations in the value of machinery purchases have been considerable. These appear to be the result mainly of the exigencies of the Soviet hard-currency balance of payments. Up to 1972, variation in the figures in Column 2 could be quite well "explained" statistically by two other variables: hard-currency grain imports and total hard-currency exports.[311] In the subsequent "détente" period, Soviet hard-currency borrowing increased sharply, and the emergency grain imports of 1972-73 were not allowed to inhibit the growth of machinery imports. However, the Western recession of the mid-1970s slowed the growth of Soviet hard-currency export earnings, and another round of emergency grain imports was necessitated by the 1975 harvest failure. As a result, Soviet indebtedness grew sharply and began to act as a constraint on machinery imports.

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311 P. Hanson, "International Technology Transfer from the West to the USSR," in Soviet Science and Technology: Domestic and Foreign Perspectives, edited by V.R. Thomas and U.M. Kruse-Vaucienne, Washington, D.C., 1977, page 363. "Looking at Soviet hard-currency imports of machinery from the West (roughly, OECD less Finland) between the mid-1950s and the early 1970s, I found that, for 1955-1971, the simple hypothesis that machinery imports in any given year (MK_t) were determined by total exports to the West in that year (X_t) and (negatively) by grain imports from the West in the previous year (MG_{t-1}), fitted the facts remarkably well.

$$MK_t = -72.42 + 0.386X_t - 0.394MG_{t-1} \qquad (R^2=0.916)$$
$$(0.934)\ (8.086)\ (-2.502)$$

(The bracketed figures under the coefficients are t statistics, and the X_t and MG_{t-1} coefficients are both significant at the 1% level.) Even if the time trend is removed from X and MK, the relationship over 1955-1971 is still quite strong. The implication is that variations in indebtedness to the West, or in gold sales, are not strongly associated with variations in machinery imports in this period. In 1972 the pattern changed. The US-Soviet trade agreement offered a major new source of credit, and emergency grain imports (on credit) were made while (unlike 1963-1964) machinery orders and deliveries continued sharply upwards. Greater use of credit was no doubt in part a response to the acceleration of Western inflation, which provided the Russians with credit at negative real interest rates. But, taken in conjunction with the other changes considered, it is surely also part of the more general policy change under discussion."

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THE ANALYSIS OF METHODOLOGIES AND TECHNIQUES FOR ESTIMATING SOV--ETC(U)

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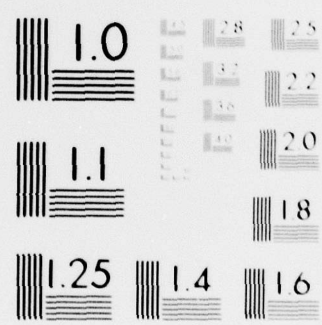

MICROCOPY RESOLUTION TEST CHART

> The limits to Soviet indebtedness were not so much set by Western banks and governments as they were self-imposed by Soviet planners....Thus, the sharp cutback in new Soviet orders for Western machinery that occurred in 1977--the first such reversal in the 1970s--most likely reflected the financial caution of Soviet policymakers, out of concern that USSR debt service in hard currency had reached what is believed to have been something on the order of 25-30 percent of hard-currency earnings for exports of merchandise other than arms.[312] One might hazard the guess that Soviet machinery orders would pick up once more if Soviet hard-currency export earnings again began to grow strongly.[313]

The underlined portion of the foregoing, somewhat lengthy explanation provided by Philip Hanson reveals the importance to the Soviet authorities of covering more of their outstanding debts with compensation agreements in order to provide additional hard-currency earnings.

The proposed changes to SOVMOD III are advocated for the purpose of testing the second hypothesis enunciated by Bill Lee at the ONR-sponsored workshop on economic conflict; i.e.,

> I would also advance the hypothesis that the rising cost of weaponry is one of the primary causes for the very low proportion of durables in Soviet investment outlays. Durables are only about one-third of new investment outlays. In other words, for each new ruble of investment, only about 35 kopecks are allocated to durables; the rest goes into brick and mortar. If you deduct housing and some other things, the ratio is still only about 40 percent. I have seen Soviet explanations of this subject which allege that, in other Western countries, this ratio is much higher...If this is the case and if the low ratio of producer durables in Soviet investment outlays has something to do with defense expenditures, then I would argue that, as a hypothesis, there is a relative shortage of producer durables which adds to the difficulty of substituting capital for labor in the Soviet economy. This situation is evidenced by the relatively modest contribution of technology to the growth of output in Western analyses of the production function of the Soviet economy.[314]

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[312] According to Philip Hanson's tally (from Western press reports), new orders decreased from approximately US $6 billion in 1976 to about US $2.5 billion in 1977. (Economist Intelligence Unit, Quarterly Economic Review of the USSR (London), Nos. 2 and 3, 1978).

[313] Philip Hanson, "Western Technologies in the Soviet Economy," Op. Cit., page 25; Table 1 may be found on page 22; parenthetical information and underlining have been added for clarity and emphasis, respectively.

[314] Appendix C, pages C-9 to C-10; underlining has been added for emphasis.

This hypothesis is modified in Appendix C as follows:

- The low percentage of producer durables may also reflect a higher Soviet priority on the development of energy resources which requires more "brick and mortar" in new investment expenditures.
- The "relative shortage" of producer durables may now be interpreted in the "qualitative" framework of the technology embodied in imported Western machinery and equipment which definitely eases the "difficulty of substituting capital for labor".
- Given the "economic necessity" to import producer durables from the West, then Bill Lee's original hypothesis with regard to a causal relationship between increased Soviet defense spending and a "relative shortage" of producer durables may be modified to reflect a "differential military burden" hypothesis with respect to the imported vs domestic stock of machinery and equipment.
- Bill Lee's modified hypothesis may therefore be stated as follows:
  - Increased Soviet National Security Expenditures (NSE) have resulted in a "military necessity" to import Western machinery and equipment in order to indirectly support the Soviet military establishment by easing the "difficulty of substituting capital for labor" in the civilian Soviet economy.
  - The "relative shortage" of producer durables in quantitative, as well as qualitative, terms merely reflects the higher priority accorded to both military durables and the development of energy resources, which requires more emphasis to be placed on "brick and mortar" than machinery and equipment.[315]

This "military necessity" hypothesis with respect to Soviet trade policy is developed in more detail in Appendix C.[316] The basic concept, however, is to estimate the relative burden differential between the Soviet stock of imported Western machinery and equipment and their stock of domestic machinery and equipment for each economic sector. If, after making allowance for the greater relative productivity of imported Western machinery and equipment (when compared to the domestic stock), the relative burden differential still exists, then this evidence would strongly suggest that a "military necessity" to import Western machinery and equipment for the embodied technology is the dominant consideration in the formulation of Soviet trade policy. Although the

[315] See Appendix C, pages C-10 to C-15.

[316] See Appendix C, pages C-99 to C-105.

actual testing of this "military necessity" hypothesis requires the use of historical time period data and the refinement of the generalized burden analysis in Appendix B as summarized in Equation (C-55) in Appendix C, it is possible to project the relative burden differential in each economic sector by using the projected composition of Soviet NSE with the methodology of Equation (C-55) in Appendix C over the projection period 1976-1985 in SOVMOD III.[317] Consequently, the four basic "sensitivity analysis" experiments originally illustrated by means of the Bergendorff-Strangert model (i.e., a change in the production function specification, a change in the technology transfer productivity specification, and a change in the estimated burden of Soviet defense spending in total and by each economic sector) have been extended to the SOVMOD III macroeconometric model--which may be summarized as follows:

- The development of an ex ante VES production function which contains the ex ante CES and Cobb-Douglas production functions as special cases;
- The re-specification of the import demand equations, to include a compensation agreements explanatory variable;
- The formulation of a relative burden analysis to test a "military necessity" hypothesis with respect to Soviet trade policy which has important implications with respect to the possible "leverage" associated with Western "technology transfer" to the Soviet Union.

The actual implementation of these four experiments within the framework of SOVMOD III and with the same three alternative allocation rules constitutes twelve "ex ante" resource allocation experiments that are suggested for future empirical and theoretical research.

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317 This possibility for the projection of the relative burden differential between the Soviet stock of imported Western machinery and equipment and their own stock of domestic machinery and equipment may be used to evaluate the possible value of "leverage" associated with "technology transfer" from the West. The recently announced role of the National Security Council in the review of export licenses for American technology being sold to the Soviet Union and other communist countries is a reflection of this type of "leverage" ("The Legacy of a Harvard Scholar: A Carefully Primed Soviet 'Bear Trap'" concerning Samuel P. Huntington in the Washington Post, August 20, 1978).

4.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 A RECAPITULATION OF RESEARCH OBJECTIVES

Generally speaking, the basic objective of the research presented in this summary report was to investigate the various issues and empirical hypotheses with respect to Soviet resource allocation which were discussed at the ONR-sponsored workshop on Economic Conflict and National Security Research in September 1976. More specifically, the issues and empirical hypotheses that relate to the estimation of Soviet National Security Expenditures may be summarized as follows:

- The nature and explanation for the various methodological differences among the various methods of estimating Soviet defense expenditures.
- The implications of these methodological differences for resource allocation within the Soviet economy when the alternative estimates of Soviet defense spending are evaluated within the framework of Soviet National Income Account data for the Gross National Product and its component elements--i.e., Consumption, Investment, and Governmental spending (both non-defense and defense).[318]
- The empirical hypothesis that there is a direct trade-off between the level of investment and the level of estimated defense spending, and that this short-run opportunity cost inhibits the growth of investment.[319]
- The empirical hypothesis that the composition of investment has been adversely affected by a "drainoff" of defense spending, as suggested by the low ratio of producer durables in new investment.[320] Inasmuch as the composition of investment may be interpreted in terms of emphasizing construction costs due to the Soviets' primary concern with "energy self-sufficiency," then the relative shortage of new domestic producer durables in qualitative terms may be alleviated by machinery imports from the West. In fact, this emphasis upon the technology transfer embodied in imports of Western machinery and equipment may even reflect a "military necessity," as well as the normal economic rationale for such imports.

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[318] This evaluation of the estimated level of Soviet defense spending is provided in Appendix A and extended to the estimated sectoral composition of Soviet defense spending in Appendix B.

[319] See pages 7 and 8 in Section 1.1.4 and page D-8 in Appendix D of this summary report.

[320] See pages 8 and 9 in Section 1.1.4 and page D-9 in Appendix D of this summary report.

These four issues and empirical hypotheses, which stem from the results of the workshop, provide the basic focus for this summary report.

4.2 A SUMMARY OF THE MAJOR SECTIONS OF THE REPORT

4.2.1 A Summary of Section 2.0

Section 2.0 of this summary report reviews the nature and explanation of the various methodological differences among the alternative baseline estimation techniques for Soviet defense spending in some detail. This review of the various methods for estimating Soviet defense expenditures is based upon the usual and additional components of Soviet NSE defined in Table 2.0. Some of these components may be related to the Defense and Science line items of the Official Soviet Budget for the historical time period 1960-1975--as reflected in Table 2.1. Inasmuch as the level of Soviet NSE may be disaggregated to the following "resource categories," then the fundamental identity for each baseline estimate is the sum of these four categories:

- Operating Budget--$\alpha_{it}(\text{Defense})_t$,
- Military R&D--$\beta_{it}(\text{Science})_t$,
- Procurement--γ_{it} , and
- Residual Category--δ_{it}

Therefore, the basic identity in Equation (1) of this report [i.e., $D_{it} = \alpha_{it}(\text{Defense})_t + \beta_{it}(\text{Science})_t + \gamma_{it} + \delta_{it}$] serves as the framework for expressing the specific methodology for estimating each resource category of Soviet NSE in terms of numerical estimates for the foregoing parameters (α_{it}, β_{it}, and γ_{it}) with δ_{it} set equal to zero. This provides the opportunity to formulate statistical tests for the significance of the observed differences in the numerical estimates of each of these parameters caused by differences among the alternative baseline methodologies. The formulas for the confidence intervals around the α_{it}, β_{it}, and γ_{it} parameters have been developed, but have not yet been empirically implemented. Instead, more emphasis has been placed upon the

identification of possible sources of methodology errors and information errors--the concepts of which have been rigorously defined. With reference to alternative procurement estimates (i.e., Y_{it}), particular emphasis has been placed upon an in-depth evaluation of the following three possible causes of bias and error:

- Double-counting bias,
- Overpricing of new products bias, and
- Comparability of establishment basis and commodity basis data.[321]

The current literature pertaining to these three sources of bias and error has been carefully reviewed.

Each numerical estimate of Soviet NSE has been associated with a curvilinear growth path as defined in Equation (32) (i.e., $D_{it} = \alpha_i \beta_i^t \delta_{it}^*$). By means of this equation, each of the baseline methodologies may be summarized in terms of the following parameters:

- Base year (i.e., t = 0)
- Growth percentage, (i.e., $b_i = 1+r_i$), and

a multiplicative composite error term (δ_{it}^*). It is within the frame of reference of this curvilinear growth path that δ_{it}^* has been conceptually partitioned into information and methodology error terms (i.e., $\delta_{it}^* = \varepsilon it \ \nu_{it}$). Therefore, assuming appropriate statistical properties for εit and ν_{it}, respectively, then a systematic methodology error parameter (i.e., ω_i) may be associated with the natural log of the base year parameter (α_i) and a systematic information error parameter (i.e., μ_i) may be associated with the natural log of the growth percentage parameter ($b_i = 1 + r_i$). Consequently, the traditional properties of an estimator, which are identified below, may be associated with the concepts of methodology and information errors:

- Consistency,
- The absence of bias,

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[321]See pages 62-80 in Section 2.6.4 of this summary report.

- Minimum variance,
- Relative efficiency, and
- Sufficiency.[322]

By analogy, a methodology error alone implies that the estimator of Soviet NSE is a sufficient statistic, but may be biased, inefficient, or even inconsistent. By contrast, an information error alone implies that the estimator is not even a sufficient statistic. However, once the information error is eliminated, then the estimator would be unbiased, consistent, and have a minimum variance. Inasmuch as the normal situation is that an estimator will reflect some unknown combination of both methodology and information errors, then it may be observed that the relative intensity of these errors among the alternative baseline techniques for estimating Soviet NSE does provide a basis for their comparison and evaluation.

4.2.2. A Summary of Section 3.0

Section 3.0 of this summary report evaluates the alternative baseline estimation methodologies in terms of their impact upon resource allocation within the Soviet economy. In Table 2.22, the set of current baseline methodology estimates of Soviet NSE for the historical time period 1960-1975 reflects a definite resource allocation problem for a given set of Soviet National Income Accounts. Inasmuch as Soviet Gross National Product (GNP) may be disaggregated into the following major end-use categories, then the basic definitional equation for GNP in each time period must be maintained:

- Consumption (C),
- Investment (I),
- Administrative Governmental expenditures (A), and
- Defense expenditures (D).

Consequently, any discrepancy between a baseline estimate, D_{it}, and the end-use category for defense, D_t, must reflect:

- "Undetected" Soviet NSE, which must be added to the estimates of Soviet GNP, or
- "Hidden" Soviet NSE in the C, I, OR A accounts, which must be properly reallocated.

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[322]See pages 110-117 in Section 2.10 of this summary report.

The motivation for this ex post resource allocation analysis was the recent CIA revision of its estimates of Soviet NSE and the question of whether or not these revised estimates are still compatible with the CIA's estimates of the Soviet GNP accounts for 1970. For example,

- Douglas Diamond of the CIA stated during a seminar at Harvard University in 1976 that approximately 25 billion rubles of Soviet NSE had been previously "undetected" and that a figure of this magnitude would have to be added to the CIA's estimate of Soviet GNP for 1970; whereas

- John Pitzer, also of the CIA, stated in a paper presented at a NATO colloquium in 1977 that enough "hidden" Soviet NSE can be identified in the Consumption, Investment, and Government Administration accounts of Soviet GNP to reconcile the recent revisions of the CIA estimates of Soviet NSE.

These two polar points of view have been supplemented by the following intermediate opinions:

- William Lee recently observed in his book that the CIA estimate of 381 billion rubles for Soviet GNP in 1970 "probably leaves the CIA accounts at least 10 billion rubles short on the sector-of-origin side of GNP because enterprise funds look implausibly low and several billion rubles of budget income are not entered"; and

- Rush Greenslade hypothesized that the Soviet GNP for 1970 was too low by about the estimated range of error of plus 5.5 billion rubles.

In light of these statements, the alternative hypothesized values for the level of "undetected" Soviet NSE was observed to range from zero (i.e., John Pitzer) to 5.5 billion rubles (i.e., Rush Greenslade) to 10 billion rubles (i.e., William Lee) to 25 billion rubles (i.e., Douglas Diamond). These alternative hypotheses with respect to the level of "undetected" Soviet NSE were combined with John Pitzer's hypothesis that 14 percent of the estimated Soviet NSE is "hidden" in the other non-defense categories of Soviet GNP. Finally, alternative estimates of Soviet military research and development expenditures were used to define a total of 20 ex post resource allocation experiments which are described in Appendix A in some detail.

The development of an econometric methodology for the reconciliation of the set of baseline estimates of Soviet NSE in Table 2.22 with the current ruble estimates of Soviet GNP was based upon the definition of a measurement error (ω_{it}) as the difference between each estimate of Soviet NSE (D_{it}) generated by the ith estimating technique and the end-use category for defense (D_t). In view of the hypothesis that 14 percent of this measurement error is "hidden"

in the other GNP accounts, then 86 percent of this measurement error must be divided into systematic and random components. The systematic component is determined by the hypothesized level of "undetected" Soviet NSE in 1970 which must be added to Soviet GNP and the estimated growth rate of Soviet GNP over the historical time period. The random component may then be associated with statistical tests on various parameters. As a result, the ranking of the baseline estimating techniques in terms of their relative "robustness" to changes in the experimental conditions underlying the 20 ex post resource allocation experiments was determined as follows:

- Very Robust -- Bill Lee's estimation technique (i.e., both the establishment basis and commodity basis);

- Moderately Robust -- The SIPRI and Chinese estimation techniques;

- Slightly Robust -- Stanley Cohn's estimation techniques (i.e., both the State Reserves Basis and Final Demand Basis), as well as the CIA estimation technique; and

- Unacceptable -- The Official Soviet Defense Budget, the IISS original budgetary technique, and the French national expenditures method. Insofar as these three baseline estimating methodologies are concerned, the estimated value of Soviet GNP for 1970 provided by the CIA would have to be considered "too high", rather than "too low", before these methodologies could be considered to be compatible with the National Income Accounts for Soviet GNP. [323]

The relative bias and the relative efficiency properties of these alternative baseline estimators of the level of Soviet NSE were determined in Section 3.0 within the context of an ex post resource allocation analysis using an "end-use" disaggregation of Soviet Gross National Product.

Section 3.0 of this report also presented a generalized burden analysis of Soviet NSE based upon a "sector-of-origin" disaggregation of Soviet Gross National Product. Due to the inherent data limitations, more emphasis was placed upon the methodology used to provide an empirical evaluation of the economic burden associated with alternative baseline estimates of the sectoral composition of Soviet NSE. This empirical evaluation was based upon the principle of opportunity costs, which has been defined by Professor Stanley Cohn as follows:

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[323] See page 150 in Section 3.5.2 of this summary report.

> Economic analysis measures the sacrifice of a particular use of resources in terms of the concept of opportunity cost. Given the limited availability of resources, both human and material, their utilization for one purpose is attained at the cost of sacrificing some other possible use. This postulate presumes full utilization of resources; i.e., full employment. The devotion of a significant share of an economy's national product to military purposes deprives the economy of the opportunity of using that output for higher levels of consumption and/or more rapid rates of growth in the form of higher levels of investment. [324]

This principle of resource allocation is implemented operationally in Appendix B by calculating the burden of Soviet military expenditures by means of an analysis of the competing uses of resources (as reflected in an input-output matrix) and the determination of possible competitive claims for scarce human and capital inputs. However, this evaluation of the alternative estimates of the sectoral composition associated with the alternative estimates of the level of Soviet NSE in Table 2.22 covers only the period 1966 - 1971. Moreover, only Bill Lee's and Stanley Cohn's estimation techniques provided the additional data required to properly implement the generalized burden analysis methodology developed in detail in Appendix B.

The original disaggregation of the estimated level of Soviet NSE into <u>three</u> primary "resource categories" was further disaggregated into the following twelve economic sectors of the Soviet economy:

- Sector 1: Agriculture,
- Sector 2: Industry -- Fuels (electric power, coal, oil and gas),
- Sector 3: Industry -- Metals (ferrous and non-ferrous),
- Sector 4: Industry -- Machinery and Equipment (machine-building),
- Sector 5: Industry -- Other Machinery and Equipment (metalworking),
- Sector 6: Industry -- Construction Materials,
- Sector 7: Industry -- Chemical and Petrochemical,
- Sector 8: Industry -- Food,
- Sector 9: Industry -- Light,
- Sector 10: Construction,
- Sector 11: Transport and Communication, and
- Sector 12: Trade and Distribution. [325]

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[324] See page B-1 in Appendix B of this summary report.

[325] See page B-19 of Appendix B of this summary report.

A set of general disaggregation rules were formulated and applied to the CIA's direct-costing estimates for Soviet defense spending in 1970, and this provided a frame of reference within which violations of the general disaggregation rules were identified on the basis of the additional data provided by Bill Lee and Stanley Cohn -- which were used to implement the methodology developed in Appendix B. The CIA may also use these same disaggregation rules in order to obtain a possible historical time series disaggregation of the direct-costing estimates of Soviet NSE by economic sector and then repeat the resource allocation experiments defined in Appendix B. The three experimental conditions which were examined are summarized as follows:

- A change in the assumption that "all technological progress appears in the final demand where fewer inputs are required over time to obtain a unit of final product";
- Elimination of the special sectoral pattern of RDT&E expenditures from the estimates of Soviet NSE by sector; and
- A test of the importance of performing the burden ratio computations with input-output data in producer's prices, instead of in purchaser's prices. 326

These three experimental conditions define eight basic experimental designs because they can be imposed one at a time, two at a time, all three at a time or not at all (i.e., the baseline case).[327] In addition, there are two primary resources, labor and capital, and each has been partitioned into three qualitative categories. Therefore, the eight basic experimental designs may be applied to each primary resource and to each qualitative category. As a result, there are eight types of resources for which economic burden ratios were calculated, and the incidence patterns of resource allocation were evaluated for the historical time period. These eight types of resources distributed by sector were defined as follows:

- Aggregate labor -- all workers;
- High-skill labor --- graduates of Higher Educational Institutions
- Middle-skill labor --- graduates of Specialized Secondary Educational Institutions,

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[326] See pages B-62 to B-64 of Appendix B of this summary report.

[327] These three experimental conditions define $2^3 = \binom{3}{0} + \binom{3}{1} + \binom{3}{2} + \binom{3}{3} = 1 + 3 + 3 + 1 = 8$ basic experimental designs which are presented in Table B-35 on page B-67 of Appendix B of this report.

- Low-skill labor --- workers who are not graduates of either of the foregoing categories of schools,
- Aggregate capital -- fixed and working capital,
- High-durability capital -- buildings and structures,
- Middle-durability capital -- machinery and equipment, and
- Low-durability capital -- total inventories.[328]

Inasmuch as there were eight types of resources and eight basic experimental designs, then 64 different experiments were performed with their associated resource allocation burden incident patterns. Those sectors which exhibited non-increasing burden ratios over the historical time period for each of the estimation techniques examined were ranked in terms of their "relative sensitivity" to changes under the three experimental conditions as follows:

- Very Sensitive
  - Labor Resource: Construction Materials (sector 6), and Trade & Distribution (sector 12);
  - Capital Resource: Agriculture (sector 1), Light Industry (sector 9), and Construction (sector 10);

- Moderately Sensitive
  - Labor Resource: Fuels (sector 2), Chemicals (sector 7), Food (sector 8), Light Industry (sector 9), and Construction (sector 10);
  - Capital Resource: Construction Materials (sector 6), Chemicals (sector 7), and Food (sector 8);

- Slightly Sensitive
  - Labor Resource: MBMW (sectors 4 and 5) and Transportation and Communication (sector 11);
  - Capital Resource: Fuels (sector 2), MBMW (sectors 4 and 5), Transportation and Communication (sector 11), and Trade & Distribution (sector 12);

- Insensitive
  - Labor Resource: Agriculture (sector 1) and Metals (sector 3); and
  - Capital Resource: Metals (sector 3).[329]

These relative sensitivity rankings provide a basis for some preliminary resource allocation conclusions with regard to those economic sectors which have absorbed the greatest impact of increased Soviet defense spending during the historical time period. In this context, it was observed that the Metals sector.

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[328] These eight types of resources by sector are presented in Table B-36 on page B-68 of Appendix B of the summary report.

[329] See page 236 in Section 3.6.5 of this summary report -- in particular, Footnote 268, which defines these categories of sensitivity.

reflected an increasing trend with respect to the burden ratio for all of the estimation techniques considered as well as all of the skill and durability categories. It was also observed that the MBMW sectors, as well as the transportation and communication sector, were considered to be "slightly sensitive" with respect to both the labor and capital resources. Therefore, it would appear that these four of the twelve economic sectors absorbed the burden of increased Soviet NSE during the period 1966 - 1971. All of the remaining eight sectors are identified as "very sensitive" or "moderately sensitive" with respect to either the labor or capital resource or both of these resources. As a consequence, it may be observed that at least one or more of the skill categories or the durability categories <u>definitely</u> avoided the burden of increased Soviet defense spending in terms of the:

- Estimation techniques considered, and
- One or more of the eight basic experimental designs.

It was also observed that these preliminary conclusions with respect to Soviet resource allocation are <u>not</u> sensitive to the choice of estimation technique.

Section 3.0 of this summary report also reviews the original findings of Steven Rosefielde with regard to the Soviet civilian labor force devoted to the production of defense goods in detail. As a result, it was observed that his findings are very sensitive to the selection of the baseline estimating methodology for the estimation of Soviet NSE. Therefore, the original six tables of final results presented by Steven Rosefielde now include the following additions, corrections, and changes:

- The value of the Soviet capital stock involved in the production of defense goods has been added to the analysis;
- The methodology errors associated with the original sectoral disaggregation of Bill Lee's and the CIA's estimates of Soviet NSE have been corrected by means of the general disaggregation rules;
- The new information reflected in Stanley Cohn's sectoral disaggregation of Soviet NSE greatly modified Steven Rosefielde's original findings, and
- The need for a sectoral disaggregation of the CIA's estimates of Soviet NSE for the historical time period was identified. [330]

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[330] See pages 132-133 of Section 3A and pages B-14 through B-59 of Appendix B of this report.

The remainder of Section 3.0 is devoted to an ex ante resource allocation analysis of the projected level, composition, and rate of growth of Soviet NSE for the projection time period 1976 - 1985. In this context, the following distinction between "predictions" and "projections" is useful:

> Projections are used for longer periods of time, but are not predictions. They (projections) are statements of what will occur under certain assumptions. Usually it is assumed that policies will remain constant, but a projection can be made on the assumption that a new policy will be adopted. Other assumptions may concern government spending, revenues, industrial production, consumption, etc. A projection is a conditional statement. The assumptions are always explicit and the high degree of uncertainty surrounding projections is always recognized. 331

Inasmuch as the assumptions and formal hypotheses required to make a projection may be best organized in the form of a model, then the Bergendorff - Strangert and SRI-WEFA SOVMOD III were examined in detail from the standpoint of Soviet ex ante resource allocation and its interaction with the alternative baseline estimation methodologies which have been analyzed in this report.

The Bergendorff - Strangert Model is a generalization of the Calmfors - Rylander (C-R) model which, in turn, is a generalization of the original Bergson "New Growth Model" of the Soviet economy. The three different approaches used by Bergendorff and Strangert to capture the ex ante trade-off between the growth rate of Soviet NSE and the growth rates of Consumption and Investment expenditures are defined in the following three basic experimental designs, respectively:

- Investment is exogenous and Consumption is endogenously determined as a residual;
- Consumption is exogenous and Investment is endogenously determined as a residual; and
- Both Consumption and Investment are endogenously determined with their shares of non-defense gross national product provided exogenously.

Within each of these experimental designs or set of allocation rules, the following four "sensitivity analysis" experiments pertaining to Soviet resource allocation were performed:

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331 Western Perceptions of Soviet Economic Trends", Richard Kaufman, Op. Cit., Page 14; underlining has been added for emphasis.

- The production function for the industrial sector is changed from Cobb-Douglas (with $\sigma = 1$) to CES (with $\sigma = 0.5$) in order to examine the consequences of an elasticity of substitution between capital and labor <u>less</u> than unity when the given rate of growth in Soviet defense expenditure changes;

- The technological progress parameter of the industrial sector production function is changed in order to examine the consequences of improved managerial performance or the importation of foreign technology when the given rate of growth in Soviet defense expenditures changes.

- The defense <u>share</u> of Soviet GNP (i.e., the burden ratio) is changed in order to examine the consequences of reducing the percentage of non-defense GNP available for Consumption and Investment when the given rate of growth in Soviet defense expenditures changes.

- The sectoral <u>composition</u> or "mix" of Soviet defense final demand between the Industrial and Construction sectors is changed in order to examine the impact upon resource allocation when the given rate of growth in Soviet defense expenditures changes.

The foregoing combination of three alternative experimental designs and four alternative sensitivity analyses constituted twelve "ex ante" resource allocation experiments for the projection of Soviet defense spending in the period 1976 - 1985 with the rate of growth parameter determined exogenously. Within the context of these twelve "ex ante" resource allocation experiments, a Soviet energy constraint was introduced to reflect the Soviet policy of maintaining "energy self-sufficiency". Finally, the relationship of these resource allocation experiments to the baseline methodology estimates of Soviet NSE presented in Table 2.22 was discussed in detail.

It was observed that the four basic "sensitivity analysis" experiments pertaining to Soviet resource allocation which were defined for the Bergendorff-Strangert model for illustrative purposes could be replicated by means of the more sophisticated SRI-WEFA SOVMOD III model along the following lines:

- The SRI-WEFA engineering approach to Soviet production was carefully reviewed and, in the process,
  - Donald Green's ex ante production function in two variables was shown to be equivalent to the more conventional Cobb-Douglas, CES, or VES production function specifications by an appropriate choice of substitution function specifications;

- The relationship between the parameters used by Professor Karl W. Roskamp in his VES production function (which contains the CES and Cobb-Douglas specifications as special cases) and the parameters used by Donald Green in his ex ante production function was rigorously established; and

- The theoretical correspondence provided a political power interpretation of wage determination, as well as an institutional rigidities interpretation of the adjustment in the capital-labor ratio to changes in the prevailing wage rate.

- The SOVMOD III demand equations for Soviet machinery imports were carefully reviewed and, in the process,

  - The original specification of the demand equations for Soviet machinery imports was changed by replacing the "détente trend" explanatory variable with a "compensation agreements" explanatory variable; and,

  - A military necessity hypothesis with respect to Soviet trade policy was formulated for testing based upon the sectoral composition of the alternative baseline estimates of Soviet NSE and the generalized burden methodology developed in Appendix B.

4.3 RECOMMENDATIONS

In addition to conducting the foregoing ex ante resource allocation experiments utilizing SOVMOD III, the following experimental and methodological research tasks are recommended:

- Iteration of the twenty ex post resource allocation experiments defined in Appendix A, to include the use of:
  - Bill Lee's National Income Accounts data in current rubles, and
  - The CIA's National Income Accounts data and original definition of Outlays n.e.c.

- Iteration of the sixty-four generalized defense burden experiments defined in Appendix B,
  - Using the general disaggregation rules and CIA estimating technique,

- Expanding the time period from 1966-1971 to 1960-1975, and
- Expanding the basic experimental conditions (i.e., technological progress, RDT&E expenditures, and the Leontief Inverse in producer's prices), to include the RAS method of incorporating technological change.

- Empirical implementation of the twelve ex ante resource allocation experiments defined in Appendix C using the SRI-WEFA SOVMOD III model, to include:
  - Changing the form of the production function from Cobb-Douglas to CES and VES,
  - Formal derivation of ex ante VES and CES production functions for the three-variable case wherein capital stock is disaggregated by source of origin (i.e., domestic or imported),
  - Investigation of conditions for an exact correspondence between the engineering approach and the second-order Taylor series expansion approach in the three-variable case, and
  - Analysis of a more general elasticity of substitution between the imported and domestic capital stock.

- Implementation of the technological transfer experimental condition in the SRI-WEFA SOVMOD III model using revised import demand equations, to include:
  - Testing alternative specifications,
  - Re-estimation of the ratio of marginal products of imported-to-domestic machinery with the VES production function and the technology transfer impact of "learning by importing",
  - Empirical testing of the military necessity hypothesis, and
  - Extension of the military necessity hypothesis to the import of CMEA (Council of Mutual Economic Assistance) machinery and equipment by the USSR.

- Methodological research involving the utilization of:
  - Statistical data for comparison of the major parameters (e.g., operating budget, military R&D, and procurement) of alternative baseline estimates, to include: the analysis of the statistical relationships among these parameters (as reflected in Section 2.6.1), and
  - Classified data to implement the statistical tests for the base year and growth percentage parameters (as reflected in Section 2.7), and

- Analysis of the possible interdependence of the methodology and information error terms in the alternative estimation techniques over time (as reflected in Section 2.10.2).